2544

Description and
Operating Manual

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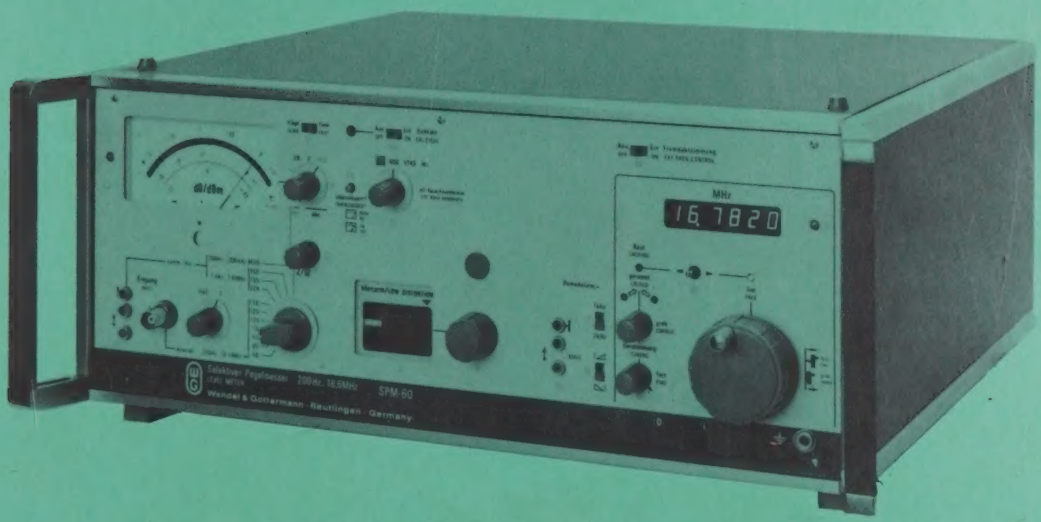


QUALITY ASSURANCE
STANDARDS, CALIBRATION, AND
MAINTENANCE LAB.

Selective Level Meter

SPM-60

for voltage level and power level measurements in the frequency range 200 Hz to 18.6 MHz

SPM-60
Selective Level Meter

for voltage level and power level measurements in the frequency range of 200 Hz to 18.6 MHz

Now from 200 Hz

- Automatic calibration and overload check
- Highly accurate measuring of levels, level magnification ±0.5 dB
- Measuring range switchable in 2 dB steps
- Six digit readout of tuned frequency; resolution, 10 Hz (max.)
- Frequency tuning through a single range
- Balanced input 124, 135, 150, 600 Ω and high impedance if requested
- Version with frequency-locking available, if requested
- Fast signal detector
- Decadic frequency settings in 1 Hz steps with OD-600

Application and characteristics

The Selective Level Meter SPM-60 is characterized by its especially high accuracy in measuring and its ease of operation. Its frequency range has been extended in the AF band commencing with Series I. The coaxial 75 Ω input versions (BN 611/0 and /4) span from 2 kHz to 18.6 MHz, whereas the BN 611/6 and /7 versions permit additional balanced measurements in the range 2 kHz to 1.6 MHz. The versions fitted with the crystal filter giving an effective bandwidth of 24 Hz [BN 611/5 (coaxial) and BN 611/8 (balanced)] enable measurements from 200 Hz or 1 kHz (124, 135, 150 Ω). Thereby, the SPM-60 fulfills all requirements of the measuring techniques with respect to the balanced, small coaxial and coaxial systems up to 3600 voice chanels.
The SPM-60 is handy to use and is portable. Operation independent of line power (e.g. man-holes with cable-fed repeaters etc.) is possible with an external battery and our Inverter WR-420.

An automatic level calibration, which makes manual calibration superfluous, guarantees high accuracy measurements throughout the whole frequency range and also affords a noticable reduction of the measuring period. The level meter is also equipped with an overload checking device, which assures that measurement errors caused by an overload of the instrument are easily noticed and thus avoided.

The SPM-60 enables the measuring of voltage levels and power levels referred to the selected input impedance. For high impedance and low capacity measurements, there are available the passive Test Probe TK-9 or the active Test Probe TK-12 with power supply TKN-12.

The measuring range is switchable in 2 dB steps from +20 dB to −90 dB (or else +26 dBm to −80 dBm). This

permits excellent resolution for level readings. Lower levels can be measured by means of the ranges −100 dB and −110 dB (or −90 dBm and −100 dBm).

Indication of the measured results is displayed on a meter having switchable scale ranges of 20 dB, 2 dB or ± 0.5 dB. The level magnifier, ± 0.5 dB, permits readings of the smallest variations to 0.01 dB in level. A fast-signal detector having an indicator lamp simplifies finding unidentified frequencies during rapid tuning through the frequency range of the Receiver.

Another worthwhile advantage of the SPM-60 is that obtained from the single tuning range of frequencies. This type of tuning has a special advantage when interference voltages are being searched for in the area of carrier frequency transmissions over radio-relay link paths. Also, it presents a great advantage in spectrum analysis measurements. The readout of the tuned frequency is done with an inbuilt counter having a max. resolution of 10 Hz. The bright and flicker-free digital readout is so distinct that even with bright ambient lighting there is good readability.

The OD-600 Decade Control Oscillator with an internal carrier frequency card permits the decadic settings of the tuning frequency[1] in small steps of 1 Hz. For frequently repeated measurements at fixed frequencies the Control Oscillator can be equipped to advantage with the ODF-601 Fixed Frequency Plug-in. A rotary switch permits selecting up to 26 preprogrammed fixed frequencies. Furthermore, the ODF-601 is switchable to automatic sequential switching whereby also individual frequencies can be blocked as chosen in advance. With remote control card, BN 614/22, the control frequency can be remotely controlled.

The high degree of selectivity and sensitivity together with the low amount of distortion introduced by the SPM-60 should be also mentioned.

The equivalent noise bandwidth of the instrument can be switched to either 1.74 kHz or 400 Hz. If requested, a 24 Hz bandfilter can be additionally fitted to the instrument. Therewith, for instance, it is possible to provide an extremely accurate analysis of a receive signal with respect to level and frequency.

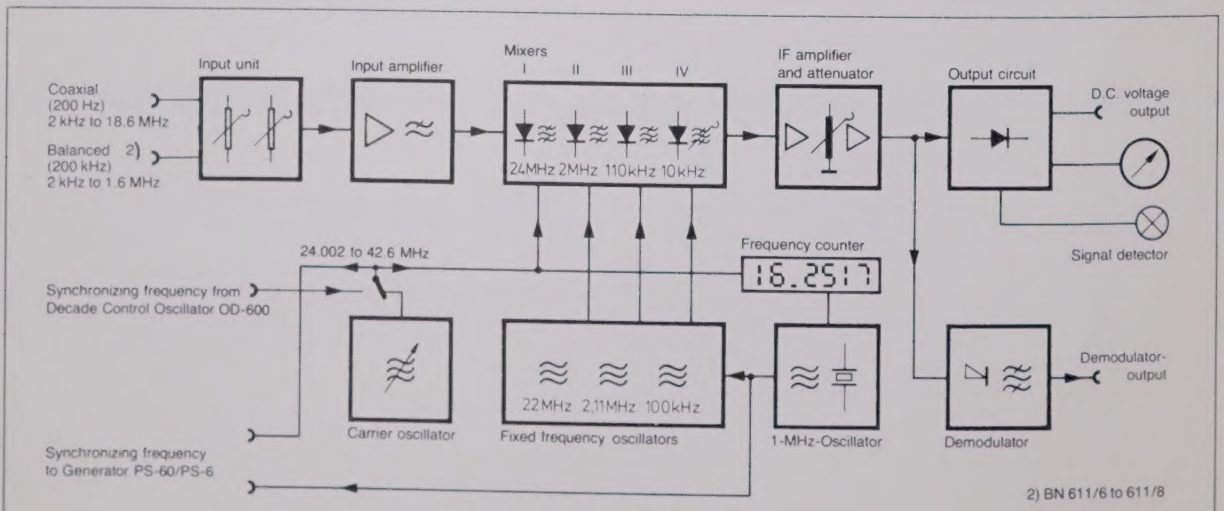
If the tuned frequency is required to have extremely high stability for measurements such as in development laboratories or in operational service, then a frequency locking device can be included with the SPM-60, when requested. Because the locked frequency is continuously adjustable, any tuned frequency in the overall frequency range can be locked to crystal stability. When the Level Meter is equipped with the 24 Hz bandwidth and the crystal-slaved frequency locking, it may be applied to measure or monitor group and super-group pilots of FDM systems while actually carrying traffic.

The demodulator accessory permits demodulating single sideband signals in upright or inverted position. The output frequency of the demodulation when tuned to the midband of the filter can be switched between 1 kHz and 2 kHz. In position, 1 kHz, phase-jitter measurements are possible in the CF range when the previously mentioned frequency locking device is also used. A phase-jitter measuring instrument complying with CCITT Recommendation O.91 is available from Wandel & Goltermann: the DLM-1 Data Circuit Test Set. For measuring interruptions according to CCITT, the measuring signal which has been converted to 2 kHz is available for further evaluation.

The Level Meter SPM-60 and either the Level Generator PS-60 or the Level Generator PS-6, can be combined to form a complete Level Measuring Setup. If Generator and Receiver are used at the same location, then by means of an extra connection between both equipments, the frequency of the Generator can be synchronously tuned at the Receiver. This considerably simplifies operation. For this case, there can be used the special Send Unit PSS-60 which does not contain a tuning oscillator. When combined with the Level Meter SPM-60, the Level Measuring Setup PSM-60 is formed. In so far as the SPM-60 has the frequency locking device included for this operating mode, this facility is also effective with the remote controlled generator.

The RFZ-5 Measurement Attachment is available for measuring return loss (coaxial, above 10 kHz), and the RFZ-12 (coaxial to 4.5 MHz and balanced). The SDZ-12 can be obtained for signal balance ratio measurements.

1) SPM-60 with series H



Simplified circuit diagram of Selective Level Meter SPM-60

Technical Details

The Level Meter SPM-60 is a receiver which operates according to the principle of multiple conversion having four different intermediate frequencies (IF's). The last IF is at 10 kHz where the most gain and selectivity is achieved.

This signal is then rectified and indicated on a meter. Simultaneously, the indicated voltage also is presented at a d.c. output connector, and there is no possibility of feedback from the load. An output from the demodulator provides the opportunity of checking single side-band signals. At two other outputs, there are the signals needed for the remote control tuning of frequencies at the Generators PS-60 or PS-6.

Such high accuracy for measuring levels is attained by means of an automatic calibrator for levels. This operates at a 1 Hz repetition rate. At this rate, the gain is checked at the pertinent tuned frequency and at the level measuring range used at that time. Then, within the same interval, the gain automatically is reset to the nominal value. A push button, for checking, enables a rapid and easy verification to determine if the Level Meter is being overdriven.

This feature prevents errors in measuring when there are large differences in levels at various frequencies presented at the input to the SPM-60.

When the OD-600 Decade Control Oscillator is used to remotely tune the Level Meter, the OD-600 control signal is substituted for the output signal of the carrier oscillator in the SPM-60 (with Series H). The relevant tuning frequency is also in this case displayed by the built-in frequency counter.

Universal connector Versacon® 9 is fitted as coaxial input chassis connector, and it permits adaptation to all the normally used cable connectors.

Specifications for the Selective Level Meter — SPM-60

All essential characteristics of our instruments are indicated by guaranteed tolerance and limit specifications and not as typical values. They are valid for each instrument not only on delivery but also for the whole guarantee period.

Unless otherwise stated, the specifications are valid for the rated range of use of the ambient temperature and the power supply immediately after the set is switched ON.

Frequency range

Unbalanced input . . . . . 200 Hz [1] to 18.6 MHz
Balanced input (with BN 611/6, /7 and /8)
Z = 124, 135, 150 Ω . . . . . 1 kHz [1] to 1.6 MHz
Z = 600 Ω . . . . . 200 Hz [1] to 300 kHz

Frequency setting continuous via coarse-fine mechanism and additional vernier detuning

Frequency display . . . . . by means of frequency counter with 6 digit flicker-free readout
Frequency resolution, switchable . . . . . 1 kHz, 100 Hz, 10 Hz
Measurements/s 77, 8, 3.3

Error limits of frequency display in rated range of use of the ambient temperature . . $\pm 9 \times 10^{-6} \pm 1$ digit of the last displayed position

Frequency locking device (with BN 611/4, /5, /7 and /8)
Temperature coefficient of tuning frequency in locked status, in limits range of operation of the ambient temperature . . . . . $\leq (\pm 5 \times 10^{-7} \pm 0.9$ Hz)/K

Level reading

With automatic calibration of amplitude switchable to voltage level (0 dB ≙ 0.775 V) or power level (0 dBm ≙ 1 mW into Z)
Measuring ranges for 0 dB meter reading . . . −110, −100, −90, −88, −86, . . ., +20 dB
−100, −90, −80, −78, −76, . . ., +26 dBm

Meter scales:
Scale range, 20 dB . . . . . −22 dB to +1 dB
Scale range, 2 dB . . . . . −2.2 dB to +0.3 dB
Scale range, ± 0.5 dB (level magnifier) . . . . . −0.5 dB to +0.5 dB

Smallest readable level difference
Scale range, 2 dB . . . . . 0.02 dB
Scale range, ± 0.5 dB . . . . . 0.01 dB

Fast signal detector
Threshold referred to 0 dB meter reading:
in scale range, 20 dB . . . . . approx. −20 dB
in scale range, 2 dB . . . . . approx. −2.1 dB

Error limits of reading for input level
Max. error of level reading in range 0 dB (+10 dBm)[2] at 0 dB reading in scale range 2 dB and at +20 °C

unbalanced input, f = 20 kHz to 6 MHz . . . . . ±0.10 dB
f = 2 kHz to 18.6 MHz . . . . . ±0.15 dB
f = 200 Hz [1] to 18.6 MHz . . . . . ±0.40 dB

1) in frequency range, f = 200 Hz or 1 kHz to 2 kHz (with Series I) with 24 Hz bandwidth
2) at 24 Hz bandwidth, the error increases: by ≤ ±0.02 dB; with appearance of a discrete impairment level at the order of magnitude of the measuring level, separated ≥ ±70 Hz from the measuring signal, by an additional ≤ ±0.02 dB (increased error).

balanced input with a source impedance Z_q = 600 Ω, input impedance Z_{in} = 600 Ω
or Z_q = 300 Ω, Z_{in} high impedance (bridging)
f = 1 kHz [1] to 200 kHz . . . . . ±0.30 dB
f = 200 Hz [1] to 300 kHz . . . . . ±0.50 dB
with a source impedance $Z_q = Z$ = 124 to 150 Ω, input impedance $Z_{in} = Z$ = 124 to 150 Ω
or $Z_q = Z/2$, Z_{in} high impedance
f = 1 kHz [1] to 620 kHz . . . . . ±0.30 dB [3]
f = 1 kHz [1] to 1.6 MHz . . . . . ±0.50 dB

Error limits of measurement range switch for f = 6 kHz to 18.6 MHz
referred to position 0 dB (+10 dBm)
in the ranges [3]: −90 dB to +8 dB (−80 dBm to +18 dBm) . . . . . ± 0.05 dB [4]
+10 dB to +20 dB (+20 dBm to +26 dBm) . . . . . ± 0.08 dB
−100 dB, −110 dB (−90 dBm, −100 dBm) . . . . . ± 1 dB

Error limits of meter scale referred to 0 dB scale mark:
Scale range, 20 dB . . . . . ± 1% f.s.d.
Scale range, 2 dB . . . . . ± 0.03 dB
Scale range, ± 0.5 dB . . . . . ± 0.015 dB

Mean temperature coefficient in limits range of operation
of ambient temperature referred to +20 °C at 0 dB meter reading:
in scale range, 2 dB . . . . . ≦ ± 0.005 dB/K
in scale range, ± 0.5 dB . . . . . ≦ ± 0.007 dB/K

Flutter of meter reading in scale ranges 2 dB, ± 0.5 dB and
"slow" setting, caused by superimposed noise with 75 Ω
input impedance in the ranges:
−90 dB to +8 dB (−80 dBm to +18 dBm) . . . . . approx. ± 0.005 dB
+10 dB to +20 dB (+20 dBm to +26 dBm) . . . . . approx. ± 0.015 dB
−100 dB, −110 dB (−90 dBm, −100 dBm) . . . . . approx. ± 0.15 dB

Deflection introduced by noise on open input, 50 Ω to 600 Ω input impedance,

f ≧ 6 kHz and bandwidth, 1.74 kHz, in position:
−90 dB (−80 dBm) . . . . . ≦ −112 dB (−102 dBm)
−100 dB (−90 dBm) . . . . . ≦ −122 dB (−112 dBm)
−100 dB (−100 dBm), unbalanced . . . . . ≦ −126 dB (−116 dBm)
balanced . . . . . ≦ −123 dB (−113 dBm)

Measuring inputs

Input for BN 611/0, /4,/5 unbalanced, connector Versacon® 9
Input impedance, unbalanced . . . . . 75 Ω and 10 kΩ ‖ approx. 45 pF
Return loss with Z_{in} = 75 Ω in ranges:
−100 dB to +20 dB (−90 dBm to +26 dBm) . . . . . ≦ 0.02
−110 dB (−100 dBm) . . . . . ≦ 0.05

Inputs for BN 611/6 to /8 unbalanced, connector Versacon® 9 and balanced, 3 pole CF connector
Input impedance, switchable
unbalanced . . . . . 50, 60, 65, 75, 124, 135, 150 Ω
and 10 kΩ ‖ approx. 45 pF
balanced (with Series I) . . . . . 124, 135, 150 Ω, 600 Ω and approx. 8 kΩ ‖ 0.7 H

Return loss: with Z_{in} = 50 Ω to 75 Ω, unbalanced in position:
−100 dB to +20 dB (−90 dBm to +26 dBm) . . . . . ≦ 0.02
−110 dB (−100 dBm) . . . . . ≦ 0.06
with Z_{in} = 124 Ω to 150 Ω, unbalanced, f ≦ 1.5 MHz . . . . . ≦ 0.01
with Z_{in} = 124 Ω to 150 Ω, balanced . . . . . ≦ 0.03

Signal balance ratio: with f ≦ 620 kHz . . . . . ≧ 35 dB
with f = 6 kHz . . . . . ≧ 70 dB

Permissible input voltage (overload limit) for all inputs
Input impedance, 50 Ω to 150 Ω . . . . . $V_{r.m.s.}$ ≦ 10 V
Input impedance, 10 kΩ: a.c. voltage . . . . . V_p ≦ 25 V
Input impedance, 10 kΩ: d.c. voltage . . . . . V ≦ 42 V

Selectivity

Switchable
"wide"
3 dB bandwidth . . . . . 2.3 kHz
Equivalent noise bandwidth . . . . . 1.74 kHz
Attenuation: at Δf ≧ ± 2 kHz (to Series G: at Δf ≧ ± 4 kHz) . . . . . ≧ 60 dB

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3) with synchronized control of the Generator from the Level Meter and with reading the send level, the specified error increases by ≦ 0.03 dB
4) in frequency range f = 2 kHz to 6 kHz, the error increases by 0.04 dB

"narrow"
3 dB bandwidth . . . . . 500 Hz
Equivalent noise bandwidth . . . . . 400 Hz
Attenuation: at $\Delta f \geqq \pm 1$ kHz . . . . . $\geqq 30$ dB
at $\Delta f \geqq \pm 2$ kHz . . . . . $\geqq 60$ dB

Pilot filter (with BN 611/5 and /8)
3 dB bandwidth . . . . . approx. 30 Hz
Equivalent noise bandwidth . . . . . approx. 24 Hz
Attenuation: at $\Delta f \geqq \pm 70$ Hz . . . . . $\geqq 26$ dB
at $\Delta f \geqq \pm 80$ Hz . . . . . $\geqq 28$ dB
at $\Delta f \geqq \pm 200$ Hz . . . . . $\geqq 40$ dB
at $\Delta f \geqq \pm 1$ kHz . . . . . $\geqq 70$ dB

IF rejection . . . . . $\geqq 80$ dB
Image frequency suppression . . . . . $\geqq 80$ dB

Self introduced distortion in position "low distortion"
at input level $\leqq \pm 10$ dB (+20 dBm) for k_2 and k_3 with an increase of sensitivity by 50 dB over the fundamental-frequency measuring range

Unbalanced: f ≥ 300 kHz . . . . . ≥ 75 dB
f = 6 kHz to 300 kHz . . . . . ≥ 65 dB
Balanced: f ≥ 300 kHz . . . . . ≥ 75 dB
f = 2 kHz to 300 kHz . . . . . ≥ 60 dB

f ≧ 300 kHz . . . . . $\geqq 75$ dB
f = 6 kHz to 300 kHz . . . . . $\geqq 65$ dB

Outputs

Unbalanced, short-circuit proof

D.C. voltage output, 3 pole CF connector . . . . . $Z_{out} = 5$ kΩ
Open circuit output voltage at 0 dB meter reading . . . . . V = 4.3 V

Demodulator output, 3 pole CF connector . . . . . $Z_{out} = 600$ Ω
Output voltage at 0 dB meter reading . . . . . approx. 0 dB across 600 Ω load
Output frequency with tuning to filter midband, switchable . . . . . 1 kHz, 2 kHz
Single sideband demodulation, switchable . . . . upright position/inverted position

Calibration cycle can be switched out; signal lamp for switched out status

Intrinsic phase-jitter of demodulator output:
(only with BN 611/4, /5, /7, and /8) complying with CCITT Recommendation O.91
In frequency-locked status of frequency tuning with bandwidth 1.74 kHz, output frequency 1 kHz
Measuring range switch in positions: −72, −52, −32 to +20 dB (−62, −42, −22, to +26 dBm):
for f = 6 kHz to 1 MHz . . . . . $\leqq 1°$
for f = 6 kHz to 18.6 MHz . . . . . $\leqq 1.5°$

Control outputs for synchronous tuning of Level Generators, PS-6, PS-60 or PSS-60

Input for synchronous tuning of SPM-60 (with Series H) by means of the OD-600 Decade Control Oscillator with carrier frequency card 24 MHz to 42.6 MHz (Option BN 614/21).

General Specifications

Permissible ambient temperature
Limit range for storage and transport . . . . . −40 °C to +60 °C
Limit range of operation . . . . . −10 °C to +50 °C
Rated range of use . . . . . +10 °C to +35 °C

Power supply
A.C. power line voltage . . . . . 110/117/127/220/227/235 V −15% to +10%
A.C. power line frequency . . . . . 45 Hz to 440 Hz
Power consumption . . . . . approx. 20 VA

Battery operation . . . . . by Inverter WR-420

Dimensions:	Bench model		19" Rack mounting (DIN 41 494)	
	Width with handles	478 mm	Width	443 mm
	Height overall	199 mm	Height	176 mm
	Depth with handles	407 mm	Depth	353 mm

Weight . . . . . 19.5 kg

Measuring Accessories

Test Probe TK-9

Passive test probe
Frequency range . . . . . 50 kHz to 18.6 MHz
Attenuation in frequency range 50 kHz to 13 MHz at 20 °C . . . . . 20 dB ± 0.1 dB
Input impedance . . . . . approx. 5 kΩ ‖ 17 pF
Permissible ambient temp. . . . . −10 °C to +50 °C
Connector, coaxial . . . . . test prod or Universal connector Versacon® 9 for all commercially available plug adapters

Test Probe TK-12

Active test probe[5]
Frequency range: unbalanced . . . . . 200 Hz to 18.6 MHz
balanced . . . . . 200 Hz to 2 MHz
Gain adjustable . . . . . 0 dB
Error limits of frequency response referred to 1 MHz:
in range, 300 Hz to 2 MHz . . . . . ± 0.05 dB
in range, 200 Hz to 18.6 MHz . . . . . ± 0.45 dB
Maximum level . . . . . 0 dB
Input impedance: unbalanced at f = 10 kHz . . . . . approx. 1 MΩ ‖ 15 pF
balanced at f = 10 kHz . . . . . approx. 1 MΩ ‖ 25 pF
Common mode voltage V_p in range, 200 Hz to 2 MHz . . . . . ≦ 2 V
Signal balance ratio in range, 200 Hz to 2 MHz . . . . . ≧ 40 dB
Intrinsic harmonic ratio: at 0 dB and f = 20 kHz . . . . . ≧ 50 dB
at 0 dB and f = 6 MHz . . . . . ≧ 40 dB

Connector, unbalanced . . . . . test prod or Universal connector Versacon® 9 for all commercially available connectors
Standard accessories . . . . 1 coaxial plug and test prod with chassis-ground clamp
If requested, available at extra cost . . . . . balanced CF plug (order No. S 804)
Power supply, TK-12 Power Supply TKN-12

Decade Control Oscillator OD-600

With carrier frequency card (option 614/21) for decadic tuning of the SPM-60 (with Series H)
Decadic frequency setting in 1 Hz steps . . . . . (200 Hz) 2 kHz to 18.6 MHz

Continuous frequency setting (option BN 614/23) via drum scale
Detuning ranges . . . . . −30 Hz to +100 Hz/−300 Hz to +1 kHz/−3 kHz to +10 kHz/−30 kHz to +100 kHz

Remote control of frequencies (option BN 614/22) . 8-4-2-1 BCD code, negative logic

Fixed Frequency Plug-in ODF-601

with programming and frequency blocking cards for . . . max. 26 fixed frequencies
Frequency selection . . . . . by switch or automatic sequencing (stepping)

Ordering Information

Selective Level Meter SPM-60:	BN 611/0
with frequency-locking device	BN 611/4
with frequency-locking device and 24 Hz bandwidth	BN 611/5
with balanced input	BN 611/6
with balanced input and frequency-locking device	BN 611/7
with balanced input, frequency-locking device and 24 Hz bandwidth	BN 611/8
Measuring accessories at extra cost	
Passive Test Probe TK-9	BN 265
Active Test Probe TK-12 with Power Supply TKN-12	BN 574 and BN 623
Return-loss Measuring Attachment RFZ-5 [6]	BN 394
Return-loss Measuring Attachment RFZ-12 [6]	BN 810
Signal balance ratio Measurement Attachment SDZ-12 [6]	BN 811
Decade Control Oscillator OD-600 with carrier frequency p.c.b.	BN 614 and BN 614/21
Fixed Frequency Plug-in ODF-601	BN 651
Inverter WR-420 [7], 11 V to 68 V	BN 678
Transportation Protective Cover for SPM-60	DE 3

5) for further data, see Specification Sheet SPM-6
6) for specs., see Specification Sheet "Measuring Accessories"
7) for specs., see Specification Sheet "WR-420"

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The instrument versions BN 611/4,/5,/7 and 8, when compared with the statements made in the "Description and Operating Manual", 611 A..., have been changed as follows :

1. Crystal controlled frequency locking

for raising the long term stability

With the help of a shiftable crystal controlled line spectrum, any chosen tuning frequency is lockable.

When the frequency lock is switched off, the chosen frequency is selected first by cranked-knob [16] . If the tuning crank [16] is "pulled-out", the frequency readout is 6 digits; frequency resolution may be increased, moreover, from 100 Hz to 10 Hz by depressing push button [4] .

After frequency lock has been switched in at bat handle switch [23] , one of the two red lamps, illuminating directional arrows, indicates the direction that knob [22] should be rotated to shift the frequency. As soon as the red lamp is extinguished, the frequency of the instrument is locked at a crystal controlled frequency. The state of being frequency locked is indicated by a green lamp next to the locking switch [23] . Now, the frequency can be exactly set by means of knob [22] . Knob [8] is provided especially for the vernier tuning when the operating mode is that with the narrow bandwidth.

The potentiometers, [22] and [8] , are only functional when the SPM-60 is in the frequency locked state, during which the frequency tuning knob [16] should not be actuated anymore.

Owing to unintentional retuning of the knob [16] or after again switching on the set, the frequency could jump out of the locked status (the green lamp is extinguished). In order that in this case the frequency can be newly locked, the bat handle switch [23] should be placed at OFF for a short time and thereafter again switched to ON. Now the frequency locking process can be repeated.

2. Demodulator output

for interruption and phase jitter measurements

The receive signal can be chosen (slide switch [17]) to be converted to either 2 kHz or 1 kHz. With that for instance interruption measurements according to CCITT, or, in frequency locked status, also phase jitter measurements are possible in conjunction with Data Circuit Test Set DLM-1 from W & G. With these measurements, the SPM-60 should be operated in the low noise ranges. With that, the automatic calibration cycle is switched off.

3. Calibration cycle switched off

Slide switch [15] located to the left of the bandwidth switch permits switching off the calibration cycle. The status "Calibration OFF" is indicated by the red warning lamp.

4. Equivalent noise bandwidth 24 Hz (not contained in versions BN 611/4,/7)

for pilot level measurements and spectrum analyses

This additional narrow bandwidth is switchable by means of bandwidth switch [3] . The 3 dB bandwidth is 30 Hz; the attenuation is 26 dB at separations of ± 70 Hz from the band centre.

SUPPLEMENT TO THE
SERVICE MANUAL

SELECTIVE LEVEL METER SPM-60
with Frequency Locking Device

Versions, BN 611/4,/5,/7 and /8, Series F...

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1. Function description, with block diagram at hand
2. Demodulator attachment (26)
3. 8 MHz oscillator and discriminator (27)
4. Control logic (28)
5. Equalizer amplifier (29)
6. Sampler (30)

Introduction

In Section 1, the function of the frequency locking device is described with block diagram at hand. Section 2 deals with the phase-locked oscillator in the demodulator which enables the above mentioned SPM-60 versions to be applied for phase jitter measurements. In sections 3 to 6, the sub-assemblies of the frequency locking device are explained in more detail. The sub-assembly numbers given in the titles above refer to the corresponding circuit diagrams in the appendix. The locations of these sub-assemblies in the SPM-60 are shown in Fig.2.

The Selective Level Meters SPM-60 BN 611/6 to /8 make available a coaxial input and a balanced input with switchable input impedances. An input signal applied to coaxial connector Bu 101 is fed via relay contacts rel 108, rel 109 and rel 104 to attenuator 1. From the balanced input Bu 102, the input signal via transformer Ü 101 and switch S 102/11/b is routed over the same path as the coaxial input signal. Switch S 101 permits the preselected impedance at the input to be switched

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in parallel to the input jack. Adjustable low-pass filters bring about minimum return loss at the input.

1. FUNCTION DESCRIPTION, WITH BLOCK DIAGRAM AT HAND

The locking circuit operates according to the following principles:

A crystal controlled oscillator provides a frequency spectrum of lines having 6 kHz spacing between the discrete frequencies. By means of the frequency locking circuit, the oscillator frequency to be locked is captured and locked onto one of the spectrum frequencies. This frequency locking function causes the tunable oscillator to be "tied" to the crystal controlled oscillator's characteristics.

In order that any chosen input frequency might be tuned in, the spectrum of comb frequencies can be continuously shifted, whereby the offset width is greater than ($\geqq$ 7 kHz), the line separation. The line comb separation of 6 kHz refers itself to the tuning of the complete instrument, and with that to the carrier oscillator (16). As a result of the carrier processing method within the SPM-60, the control oscillator (12) oscillates at one third of the carrier frequency, i.e. the comb separation is also one-third; that is, 2 kHz.

The locking circuit contains a sampler phasemeter (30) for sampling at 2 kHz the control oscillator (12) frequency. With the voltage derived from the phase comparison, after amplification and filtering, equalizer amplifier (29) offers a correcting voltage. This correcting voltage is applied to the control oscillator, where it readjusts the frequency.

The sampler operates with so-called dual sampling (see Section 6.) and receives its 2 kHz reference frequency via a frequency divider (on the control logic p.c.b. (28), from a crystal controlled oscillator sub-assembly (27), 8 MHz oscillator and discriminator). In order to shift the frequency comb, referred to the input of the Level Meter, the sampling frequency and with that also the 8 MHz crystal oscillator are tunable. The greatest relative retuning of the frequency comb is possible at the lowest tuning frequency, that is at the carrier frequency, f = 24 MHz.

It is equal to:

$$\frac{\Delta f}{\Delta f} = \frac{7\ \text{MHz}}{24\ \text{MHz}} \approx 3 \times 10^{-4} = \pm 1.5 \times 10^{-4}$$

The 8 MHz oscillator in (27) is also retunable about this relative retuning, or as an absolute value:

$$\Delta f_q = \pm 1.5 \times 10^{-4} \times 8 \text{ MHz}$$

$$\Delta f_q = \pm 1.2 \text{ kHz}$$

That means the quartz oscillator, whose mean nominal frequency is 8.003 MHz, can actually oscillate in range from 8.0018 MHz to 8.0042 MHz.

For reasons of long-term stability, (temperature drift), subassembly (27) must be matched to the 1 MHz standard frequency crystal controlled oscillator (11). The matching circuitry is located in (27) which operates as an automatic frequency control loop. A pulse shaper stage distorts the 1 MHz signal in a way that introduces a large 8 MHz spectral component. This 8 MHz "standard" frequency is mixed with a signal from the above cited oscillating range if the quartz oscillator. The output signal from the mixer is at a difference frequency located in the range 1.8 kHz to 4.2 kHz. The signal is amplified and fed to a discriminator. Thereafter, the discriminator output is a d.c. voltage representing a measure of the actual frequency from the crystal controlled oscillator. In a differential amplifier, this value is compared to the nominal value preset by the frequency vernier tuning potentiometers (P 2703 and P 2704 on the front panel). The differential amplifier output voltage is fed direct to the control input of the quartz oscillator, and with that the control loop is closed.

The required internal control procedure of the frequency locking circuitry takes place in the control logic (28).

During the locking process, the frequency locking circuit has the following processes taking place: if the frequency locking switch is at "off", the phase lock loop (control oscillator (12), sampler (30), equalizer amplifier (29)) is electronically opened, the sampling pulse is disenabled, the voltage dependant capacitor in the control oscillator (12) is connected to a fixed d.c. voltage, the quartz oscillator in the AFC circuit (27) oscillates near the "left" boundary. After the locking switch has been switched on, the phase locked loop remains electronically out of the circuit, and also the voltage dependant capacitor remains connected to the d.c. voltage. But the sampling pulse for the sampler is released. Now, a ramp

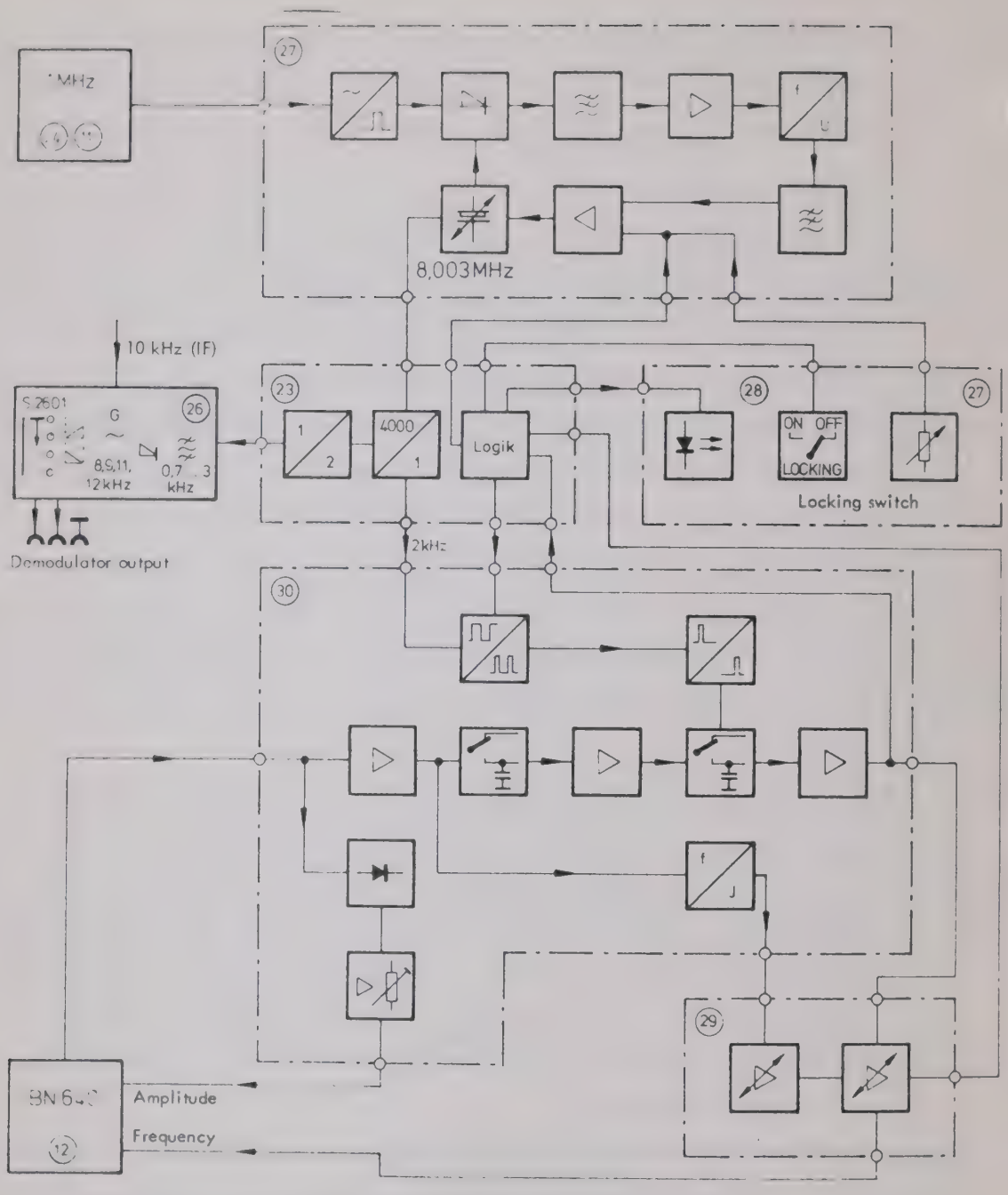
shaped sweep voltage is applied to the control input of the 8 MHz quartz oscillator in (27) (for a single shot). This causes the line spectrum to shift upwards for about 1.5 seconds. The beginning of the shift is at the internal frequency boundry.

During this automatic search process, a frequency evaluating circuit measures at the the sampler output the instantaneous frequency difference between the fixed input frequency (from (12)) and the swept comb frequency. If the two frequencies are nearly the same, that is when output frequency is nearly at null (<110 Hz), then the sweep process is stopped. At that comb frequency, the particular voltage value, representing the swept frequency, is stored in an analog store. Then the voltage occurring from the vernier tuning potentiometer setting is compared to the stored value. According to the magnitude of the measured potentiometer voltage, and after comparison with the stored nominal value, one of the two LED direction indicators illuminates. At the same instant, the potentiometer, correlated with that LED, takes over control of the frequency comb. Direction of rotation is indicated by the illuminated LED, and the potentiometer is rotated until the two voltages are made equal.

During this manual shifting of the frequency comb, the frequency evaluation circuit observes, as it did with the automatic search process, the sampler output frequency.

When the two frequencies coincide, the freq. eval. circuit switches in the phase lock loop. The electronic switch is functional from the zero crossings of the difference frequency at the sampler output. With this locking procedure the indicator for direction of rotation is extinguished, and the green lamp illuminates to indicate locking has occurred.
If now, in locked status, the fine tuning potentiometer is again tuned, the closed control loop provides that the control oscillator (12) frequency momentarily follows the frequency comb; the loop remains locked.

In the locked state of the automatic control loop and also at the sampler output, a monitoring circuit functions to inspect the correct state of locking. The automatic control loop is then correctly locked when the output voltage of the sampler is a pure d.c. The presence of residual a.c. voltage causes phase jitter because the output voltage is applied directly to the voltage variable capacitor in (12).



(12) Tuning oscillator BN 640
(24) 1 MHz Standard frequency
(26) Demodulator attachment
(27) 8.0125 MHz oscillator and discriminator
(28) Control logic
(29) Equalizer amplifier
(30) Sampler

Fig. 1 Block diagram of the frequency lock circuit

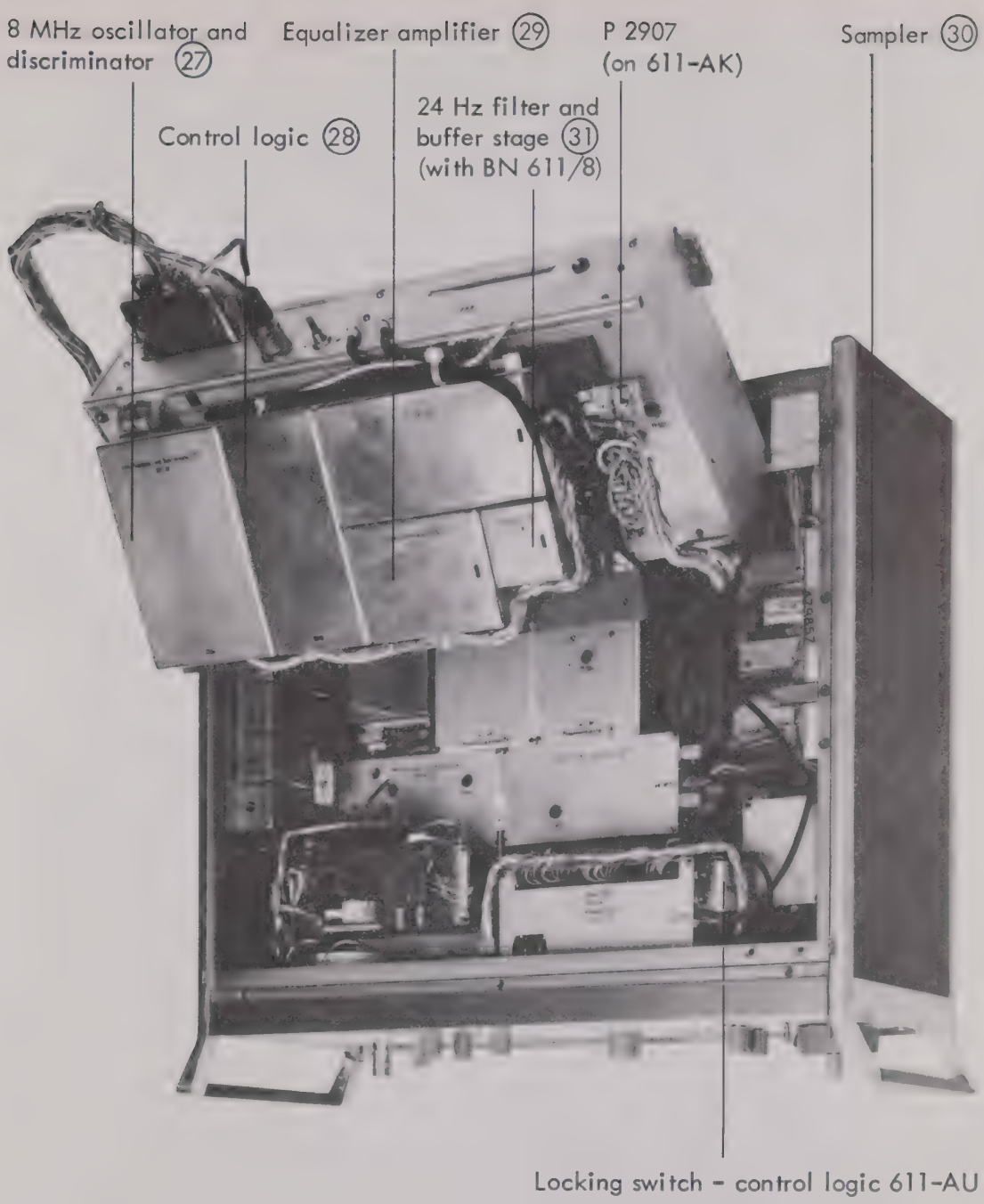

8 MHz oscillator and discriminator (27)
Equalizer amplifier (29)
P 2907 (on 611-AK)
Sampler (30)
Control logic (28)
24 Hz filter and buffer stage (31) (with BN 611/8)
Locking switch - control logic 611-AU

Fig. 2 Subassembly of the frequency locking device in the SPM-60 (p.c.b. mountings are swung out of the bottom of the hinged chassis)

This monitoring circuit determines whether a.c. voltage components are present during the 2 second monitoring cycle. If a.c. components are present, then the auto. control loop is opened. With that, the voltage variable capacitor in (12) is again applied to the fixed d.c. voltage, the a.f.c. circuit (27) operates by being drawn down to the lower boundary, and the green LOCKING indicator is extinguished. The SPM-60 then functions as when the switch position is at LOCKING "off".

Another signal, derived from the 2:1 division of the 2 kHz signal, is delivered by subassembly (28). This 1 kHz signal is routed to the demodulator attachment (26) and serves as a reference frequency for its oscillator. Again by means of a phase lock loop circuit, the slave oscillator is locked to 1 kHz multiples, thus permitting also a jitter-free and frequency stable conversion to the last IF at the demodulated output.

2. DEMODULATOR ATTACHMENT (26)

The demodulator attachments used in the instruments having the frequency locking facility are different only in the type of slave oscillator. The oscillator is a phase locked loop oscillator (see Fig. 3).

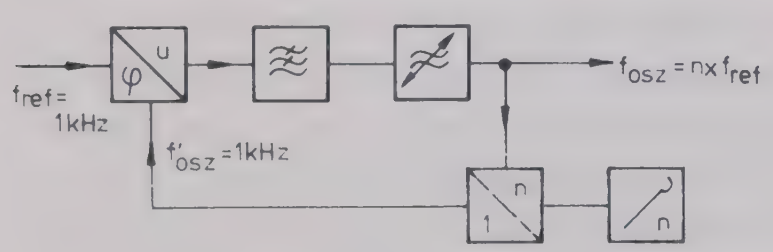


Fig. 3 Simplified Block Diagram

In the phase comparator, the oscillator frequency f'_{osc} after being divided by n is compared with the crystal controlled reference frequency f_{ref} (derived from the 8 MHz oscillator). The d.c. voltage obtained from the phase comparison is fed via a low-pass filter to the input of the voltage controlled oscillator. The d.c. retunes the oscillator until $f'_{osc} = f_{ref}$.

Since the oscillator frequency is divided by the factor n, the input to the divider is $n \times f_{ref}$, the same as at the oscillator output and with the same accuracy.

In the forgoing case, the divider is switchable: n = 8, 9, 11 and 12; i.e. the oscillator oscillates at f = 8, 9, 11 or 12 kHz. The practical controlling circuit is made up from two IC's (IC 2605 as a PLL circuit, IC 2606 as a divider); R 2669, R 2668 and C 2625 (low-pass filter).

3. 8 MHz OSCILLATOR AND DISCRIMINATOR (27)

The 1 MHz standard frequency from the basic unit is fed via Bu 2701 to the common base stage T 2701. The resulting amplified sinusoidal voltage is applied to the limiter stage IC 2701/3.1 for forming a rectangular wave shape. After this rectangular signal has been differentiated (C 2706 and R 2713), it is fed to the mixer stage IC 2701/3.2 and IC 2701/3.3 for increasing the 8 MHz component. The carrier for this mixer is routed over the pulse transformer and buffer stages T 2707, T 2706 and T 2714 direct from the quartz oscillator, T 2712 and T 2713, oscillating in the range 8.003 MHz ± 1.2 kHz. Potentiometer 2701 balances out offset variations in the mixer as well as tolerances in the differentiating network and fluctuations in the rectangular wave voltage.

At the mixer output, the wanted signal is located, depending upon the tunable quartz oscillator frequency at the time, in the range between 1.8 kHz and 4.2 kHz.

After the unwanted mixer output frequencies have been filtered out through C 2711 and C 2714, the wanted signal is amplified by T 2702 and T 2703 and is fed to the Schmitt trigger, IC 2703. The resulting rectangular shaped signal controls IC 2704 operating as a 2:1 frequency divider. The output frequency appearing at pin 9, is thereby located in the range from 900 Hz to 2.1 kHz. This symmetrical square wave signal is applied to T 2711. In conjunction with R 2765, R 2766 and C 2739, T 2711 forms a discriminator operating according to the following principles: if the transistor is cut-off, capacitor C 2739 is charged to a voltage dependant on the length of time elapsed while charging; or, in other words dependant on the frequency. But if the transistor conducts, then the capacitor discharges, and because of the short discharge time constant compared to the longer charge time constant, the capacitor can be completely discharged.

From that process, pulse sequences are provided as shown in Fig. 4

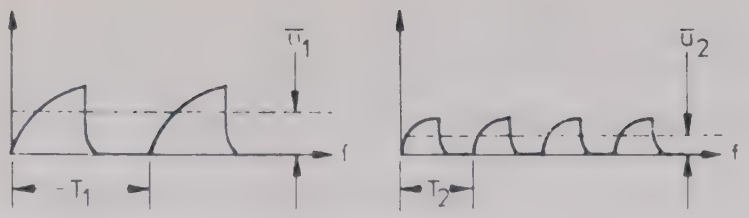


Fig. 4 Voltage trace on capacitor C 2379

Dependant on the frequency (e.g. $f_1 < f_2$, therefore $T_1 > T_2$) the charging rate of the capacitor varies and with that the mean value $\bar{u}$ of capacitor voltage (thus $\bar{u}_1 > \bar{u}_2$). From that, the desired variation of voltage $\bar{u}$ with frequency is given.

The mean value formation of the pulse shped capacitor voltage takes place in the RC filter network R 2767 and C 2741. The remaining ripple is filtered out from the unipotential voltage (the mean value) by means of the following RC networks (R 2780, C 2747 and R 2781, C 2748) and also the integrating differential amplifier IC 2705. The output voltage from this amplifier directly controls the voltage variable capacitor of the tunable quartz oscillator comprising transistor T 2712 and T 2713, and with that closes the control loop.

Additionally, in the differential amplifier, IC 2705, the nominal-actual comparison is accomplished for the control loop (quartz oscillator, mixer, discriminator, control input quartz oscillator). The differential amplifier receives a reference voltage applied to its non-inverting input (pin 3), and the control loop provides for the same value of voltage appearing at the inverting input (pin 2): thereto, the oscillator frequency is tuned in a way that the difference frequency produced by the mixer and applied to the discriminator is converted to the same value voltage at the discriminator output. The potentiometer P 2703 (FINE frequency) adjusts the reference voltage and thereby directly governs the output frequency of the subassembly. The potentiometer taps a voltage at a voltage divider (R 2769, R 2770, R 2771, R 2772, R 2768) onto which the discriminator is connected at floating points (to decrease noise effects).

Via the potentiometer P 2704 (knob on the front panel) and R 2779, a variable auxiliary current is fed into the divider. By that means, it is possible to vary even finer the frequency.

Frequency divider chain for sampling frequency

The frequency generated in the 8 MHz crystal controlled oscillator (27) is divided down to 2 kHz by the divider chain, IC 2809, IC 2810 and IC 2811, and is available at the emitter of T 2810 for use by the sampler (30). The 1 kHz signal required by the demodulator attachment (26) is coupled-out from the first binary counter of IC 2805.

Amplitude and frequency evaluations of the sampler signal

The controlling voltage produced in the sampler (30) is fed via C 2801 to the input of IC 2812/2.2. In order to acquire the noise voltage superimposed on the controlling voltage ($V_s > 80$ mV), R 2801 divides the IC 2812/2.2 output voltage and thus produces a bias voltage at the following comparator. Noise signals larger than the threshold are fed via the pulse stage (T 2802) to the input IC 2803 input and are counted there. If more than 512 events occur within 1.8 s, the counter overflow forces the phase locked loop to go out of lock.

The same counter introduces an operating time constraint. A square wave signal (period ≈ 0.26 s) passes through gate circuits IC 2802/4.3 and 4.2. After 2 minutes 10 sec., an overflow signal also appears to prevent a later locking action. This state is signalled by the directional signal being extinguished.

The square wave signal is coupled out of the counter IC 2805. The reset signal for IC 2803 (time interval 1.8 s) needed because of the locked phase control loop is fed out from IC 2805 through the gate circuit IC 2806/3.3.

For large signal amplitudes, such as those appearing in an open phase lock loop, IC 2812/2.2 commencing at approx. 10 Hz operates as a limiter. The output signal transitions nearly correspond to the input signal zero crossings. These zero crossing significant instants are transferred to the C-MOS-gate circuit via T 2802 (negative pulse dwell time < 0.5 ms). The controlling circuit is then switched in only when the sampler signal frequency (at (30) M) is located within the approx. 110 Hz capture range. For higher frequencies, the controlling circuit is disenabled by means of a post-triggerable monostable type of gate circuit (IC 2807). The pulse shaped

sampler signal is only fed to the monostable output, if sampler signal has a period longer than the dwell time of the monostable. In the reversed case, IC 2807 delivers a static preparatory signal for the JK store, IC 2808.

Control logic-status store

The locking circuit recognizes five different operating states realizable through three static stores: store I (IC 2802/2.2), store II (IC 2808/2.1), toggle switch for LOCKING mode (S 2801).

Operating state	Locking switch	Store I IC 2808/2.2 (pin 15)	Store II IC 2808/2.1 (pin 1)
1. SPM-60 normal operation	Off	static reset signal "L" of the locking switch	static reset signal "L" of the locking switch
2. SPM-60 preselection locking Spectral line sweeping	On	L	L
3. SPM-60 preselection locking Adjustment of spectral lines Manual	On	H	L
4. SPM-60 locking mode Control loop is closed	On	H	H
5. SPM-60 normal mode Control loop is open Store closed	On	L	H
		logical states	

The above table leads to five operating modes and gives the relevant states of the stores.

The LOCKING switch S 2801 requires a bistable toggle stage (IC 2801.1.) connected after it in order to suppress contact bounce effects. The time constant circuit C 2801, R 2809 prevents the occurrance of a false control process when the SPM-60 is switched on, and the preselected lock setting is ON.

Store I and store II are disenabled oppositely so that once operating state 5 has been attained, it can be left only after the LOCKING switch has again been actuated. Accordingly, operating state 1 always follows operating state 5. For the normal locking process, store I and store II are only controlled through impulses from the frequency evaluation circuit. These pulses are simultaneously offered to stores I and II. But store II can evaluate only if a delay time has elapsed after a carryover from store I. This delay in enablement bridges the build-up time

needed for the frequency control loop to be coupled to the spectral line potentiometer circuit. C 2811 and R 2826 bring about this delay. Operational amplifier IC 2801/1.2 functions as the comparator for the 5 V threshold voltage. GI 2801 prevents an overblocking of T 2801.

Otherwise, only counter IC 2803 still has an effect on the stores. The overflow signal from IC 2803 exists if there is a disturbance (also see previous section concerning frequency evaluation), and it causes operating state 5 to exist.

Automatic shifting of spectral lines (frequency comb)

The high impedance frequency comb shifting circuit connected to point (28) 13 is made inopperative in operating state 2, by means of the low impedance type circuit of FET T 2812. Now, as controlling quantity for the reference frequency comb, the output voltage from operational amplifier IC 2801/2.1 is used. This voltage is output by the analog store C 2812. It is discharged by a constant current through T 2807 from its maximum output value, +5 V, when the mode is operating state 2. If there is possibility of locking, then in operating state 3, the constant current is switched off. The high impedance buffer stage T 2808, T 2809 prevents C 2812 from discharging. This stage is set at unity gain by means of negative feedback. Voltage divider, R 2841 and R 2842, provides that the necessary voltage deviation of C 2812 is matched to the voltage range of P 2703. During the time that operating states 1, 4 and 5 are in effect, C 2812 charges to max. value via T 2806. ($V_{max.}$ C 2812 = +5 V). The lowest voltage on C 2812 ($V_{min.}$ = +2.2 V) is presented when T 2807 is fully conducting. It is determined by voltage divider R 2836 and R 2837 and a base-emitter threshold.

Control of LED's

The green locking indicator is illuminated simultaneously with the closing of the phase locked loop. The control loop is controlled by the gate circuit IC 2804/4.4 when the operating state 4 is achieved. T 2804 controls the locking indicator. During operating state 3, the evaluation for the direction of rotation is done by comparator IC 2801/2.2. The direction of rotation indicators (GI 2806, GI 2807) provide the visual signal for showing the direction that the frequency comb potentiometer must be rotated in order to permit locking to take place. During this

operating state, FET switch T 2812 is high impedance; so that the comparator can compare the analog store voltage with the instantaneous voltage value of the reference spectrum potentiometer P 2703.

T 2814 and T 2815 are connected as a differential amplifier. The low impedance voltage divider with R 2830 controls the working point of the stage and thereby the LED's (Gl 2806, Gl 2807) are switched on or off. The comparator IC 2801/2.2 via the high impedance voltage divider with R 2840 controls the current division in the differential amplifier. Because of the comparator recognizing only either of two states, the current division occurs in a way that the LED's only illuminate as one or the other to show direction.

Locking switch (with Series H)

When the frequency lock is switched out, current flows through LED Gl 2809 and indicates free use of frequency tuning knob at (12). The open switch contacts of S 2801 and the cut off transistor, T 2812, assure that T 2822 is cut-off. T 2823 conducts so that points 39 and 12 are switched to +12 V.
This corresponds to operating state 1.

In order to "lock" the SPM-60, it is sufficient to place switch S 2801 in position 1 (left) LOCKED for a short time (0.05 s). C 2821 charges immediately. After the switch had been released, the discharge current from the electrolytic capacitor holds transistor T2822 open for approx. 2.5 s.

Connection point 39 is pulled to -12 V through R 2880 and R 2809 because T2823 cuts off. LED, Gl 2809, is extinguished and the control logic obtains the "start instruction" for operating state 2.

Before the dwell time has elapsed, one of diodes Gl 2806...Gl 2808 illuminate. (The sweep time of the control logic demands a max. of 1.5 s). When one of the diodes is illuminated, T 2821 is assuredly conducting, and thus, via the high impedance feed-back resistor R 2874, C 2821 is prevented from discharging.

The locking switch remains electrically in the position LOCKED. This stored information can only be removed by the appearance of operating state 5 (extinguished LED's Gl 2806...Gl 2808), or through actuating the toggle switch to position 2

(right), FREE. The control logic reacts with almost no delay. By means of GI 2806 ...GI 2808 being extinguished the locking switch remains in the FREE position.

With switched on external control, the SPM-60 causes connection points (28) 29, 12 to be switched to +12 V via S 3301. Thereupon T 2823 is inoperative; the locking circuit switches off completely, and LED GI 2809 is continuously illuminated.

5. EQUALIZER AMPLIFIER (29)

For the situation where the SPM-60 is operated without frequency locking, the voltage variable capacitor of the control oscillator (12) is blocked off from the high impedance voltage divider: P 2907, R 2959, R 2960.

In the frequency locked case, however, the low impedance circuitry of the FET (T 2911) suppresses the influence of the high impedance voltage divider. The output amplifier IC 2902 has adjustable gain by means of P 2906.

With this adjustment, the voltage deviation needed for a definite frequency deviation (4 kHz) is matched to the "pinch" diodes defined voltage range ($0.9\ V \leqq V_{(29)\ c} \leqq 2.5\ V$). The output voltage range is: $+1\ V \leqq V_a \leqq +9.5\ V$.

As reference voltage (V (29) f), also the mean voltage (≈ 4.25 V) of the voltage variable capacitor is used. This reference voltage is derived through transistor T 2912 from voltage divider (R 2928, R 2930, R 2932, R 2937, GI 2901, GI 2908). The control loop filter (R 2948, C 2908, R 2952, C 2910, R 2949) is connected in front of amplifier stage IC 2902. This low-pass filter is driven from IC 2901. IC 2901 is set at fixed gain ($V = +1.24$) and with IC 2902 completes the matching of the "pinch" diodes' voltage range ($0.9 \leqq V_{(29)\ c} \leqq 2.5$ V) to the voltage variable capacitor's voltage.

The NTC resistor R 2936 compensates the temperature coefficient of the slope of the double transistor T 2906.

The linearizing diodes (GI 2902...GI 2905) are connected in parallel with the working resistors (R 2915, P 2902) of the differential stage T 2904, T 2905. Each diode is referred to another quiescent voltage, each with a different internal resistance. As the voltage raises across the working resistor, the voltage across the

internal resistance drops by the same amount, and thereby the gain drops proportionally. In order to match the amplification characteristic curve ot the various examples of voltage variable capacitors, P 2902 permits adjustment to reduce the effect of the diodes.

The adjustment with P 2902 not only affects the linearization but also changes the basic gains of the differential stage T 2904, T 2905. Separate adjustments of the gains may be made with P 2902. The correct working point of this differential stage is adjusted with P 2901 setting the split constant current source T 2901, T 2903. The current source is divided in order that the gain setting (P 2903) can be accomplished with only a trimmer. The balanced drive of the linearizing stage is done through double transistor T 2906.

The differential amplifier T 2906, T 2906' operates without feedback so that with one emitter current control, a gain change(5.6:1) can be achieved. This gain change is necessary to compensate for the variation of characteristic curve slope as the control oscillator (12) is tuned over its range. A discriminator in the sub-assembly sampler (30) feeds a d.c. into point (29) 4. The d.c. is dependant on the instantaneous frequency of control oscillator (12). A constant component of this current is drawn from T 2908. The linearizing circuit Gl 2906, R 2922 and the T 2909 stage converts this current component into emitter current for T 2906. With the P 2905 adjustment, at the same time, the tolerance error of the discriminator is balanced out, and the gain relationship (5.6:1) of the T 2906 stage is adjusted, in the control oscillator's (12) frequency range, 8 to 14.2 MHz.

The differential stage T 2906 reaches its overload limits for a permissible gain fluctuation of 1 dB with an input voltage of ± 15 mV. The d.c. signal from the sampler applied via the control loop switch T 2914 is divided down to the correct input value by means of R 2916 and R 2917. The offset compensation (± 10 mV) for the double transistor T 2906 is done with P 2904.

Separating the control loop, necessary for switching the locking on or off, is accomplished at two places in the equalizer amplifier. The output separation occurs when T 2911 relinquishes the high impedance voltage divider R 2959, R 2960 as the setting input to the control oscillator (12) is separated. The equalizer amplifier input is switched via T 2914.

When T 2913 is cut-off, R 2955 causes the T 2911 drain-source resistance to be its smallest value (r_{DS} = 30 Ω). Diode GI 2909 is sufficient as isolation between the two FET switches because it assures that the potential at (29) d is always more positive than at (29) 2.

T 2910 and T 2913 serve for matching the C-MOS signal of (28) 1 to the control line of the control loop switch. They provide the electronic control to the switch from the control logic (28) .

6. SAMPLER (30)

The HF signal comes from the control oscillator (12) via point 12 to the circuit input. It passes from there via C 3004 and diode GI 3002 and is applied as a rectified signal to the control amplifier for the automatic amplitude control of the oscillator amplitude (T 3001, T 3002, T 3003). Potentiometer P 3001 sets the reference voltage and with that the oscillator amplitude as long as the control loop is closed through control output, point 4.

From input point 12, the oscillator signal is also fed to the input amplifier (T 3005 ...T 3010). For the HF signal, there are transistors T 3007...T 3010, connected as complementary Darlington emitter followers.

The automatically controlled oscillator signal is available at low impedance at the output of the input amplifier. Here, two different circuit sections are applied.

One section is involved with the signal voltage being applied via C 3015 to the inductance L 3002 which as a frequency variant apparant resistance permits frequency variant a.c. to flow through the emitter of the common base stage T 3011. This a.c. is rectified in the stage comprising T 3004 and GI 3003, and after being filtered by C 3005, is available at point 1 of the circuit, the output of the discriminator.

The other section has the signal routed from the input amplifier through C 3019 to the diode bridge of the first sampler (GI 3004...GI 3007, Ü 3001, T 3016) whose store is C 3027. IC 3001 is the buffer amplifier between the first and the second sampler. High impedance input is brought about by using as pre-amplifier the FET differential stage T 3020 and T 3020' . Potentiometer P 3002 permits the offset

compensation of this amplifier stage, and also the balancing out of any residual voltages that might be present across the diode bridge of the first sampler. The decoupling amplifier following IC 3001 is the switch for the second sampler, T 3024, through which the storage capacitor C 3039 of the second sampler is switched in or out of the circuit. Buffer amplifier T 3025, T 3025' and T 3026 assure that the capacitor voltage is taken off at high impedance and output at low impedance at point 7, the circuit output.

The chronologically staggered signal drive of the two sampler stages takes place with the help of two monostable multivibrators. One of the multivibrators comprises transistors T 3015, T 3017, T 3018, T 3019, and the second comprises T 3021...T 3023. The 2 kHz reference signal is fed through point 10 of the circuit. It is a rectangular wave at MOS level; whereby the negative transition triggers the first multivibrator via diode GI 3009. The output quiescent voltage, of this stage C (point b) is +12 V. After being triggered, it puts out a negative going pulse, nearly to zero, with a duration of 1 µs. The negative transition of this pulse triggers the blocking oscillator T 3016 of the first sampler, and thus initiates the first sampling process. The positive lagging transition of the pulse at point b now triggers the second multivibrator which during its 50 µs dwell time, blocked transistor T 3023, and with that caused transistor switch T 3024 to conduct.

If the locking circuit is switched out, then the 2 kHz reference signal at the circuit input is fed out at low impedance via diode GI 3008. The control takes place via point 9 of the circuit. In normal operation, point 9 is at -12 V, therefore GI 3008 is cut-off, and the 2 kHz signal may trigger the first multivibrator. In contrast, for sampling, point 9 is at +12 V. Affected by the lower threshold voltage of GI 3008 compared to that of GI 3009, the 2 kHz pulse is fed out via GI 3008 and the multivibrator remains untriggered.

SELECTIVE LEVEL METER SPM-60

for the frequency range 2 kHz to 18.6 MHz

Description and Operating Manual 611 A...

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INTRODUCTION

The Selective Level Meter SPM-60 is characterized through high accuracy in measuring selectivity and sensitivity as well as being easy to use. For simplifying the operation of it, a single tuning range extends from 2 kHz to 18.6MHz. For this reason, the Level Meter is especially suitable for measurements on wideband carrier frequency systems. The capability for tuning over one single range offers a special advantage in searching for impairment frequencies in the range of carrier frequency transmissions over radio-links or for frequency spectrum analysis.

Additionally, operation is simplified with the automatic level calibration which markedly decreases the measuring time but affords the assurance of high accuracy in measuring levels over the entire frequency range.

The inbuilt check for over-driven condition permits easy recognition of invalid measurements caused by over-driving the Receiver. The equivalent-noise bandwidth is switchable between 1.74 kHz and 400 Hz. Additionally, if chosen, the SPM-60 can be fitted with a narrow-band (24 Hz) filter[1] which enables the exact analysis of a receive signal according to level and frequency.

As a result of the high resetting accuracy of the frequency tuning, it is possible that in equipments having narrow-band filters, the group and super-group pilots of CF systems can be measured even while the channels are carrying actual traffic.

An earphone output with single side-band demodulator permits the monitoring of the modulation in channels being measured.

The SPM-60 allows measurements of voltage level or power level to be made. For high impedance and low capacity measurements, there is a choice of the passive Test Probe TK-9 or the active Test Probe TK-12 with power supply TKN-12.

A fast signal detector with indicator lamp simplifies the discovery of unknown receive frequencies when the frequency tuning is very rapid.

Indication of the tuned frequency is done on a frequency counter having a 6 digit readout (max. resolution 10 Hz) whose bright and flicker-free numerals can be easily read even when the ambient lighting conditions are difficult due to glare etc.

The measuring range of the SPM-60 is between + 20 dB and - 110 dB (or + 26 dBm and - 100 dBm) referred to 0 dB meter reading. Range changing is done with only one switch.

Measured results are indicated on an analog meter with 3 switchable ranges 20 dB, 2 dB and ± 0.5 dB (level magnifier). With the aid of the level magnifier ± 0.5 dB, extremely accurate measurements of level variation with frequency, and the smallest variations of 0.01 dB can be read.

The Level Meter SPM-60 enables a complete Level Measuring Setup to be assembled when a Level Generator PS-60, PSS-60 or PS-6 is combined with it. If both Generator and Meter are to be operated in the same location, then via an auxiliary connection, the send frequency can be synchronously tuned from the SPM-60. As a consequence of the compatibility between equipments of the type 6 series and the type 60 series, the measuring problem at hand can be used for selection for the most useful configuration of measuring setup, (see Measuring Setup Configurations for the type series 6 and 60).

The SPM-60 can be used either on a.c. line power or independent of power lines if the Inverter WR-420 is used with an external battery.

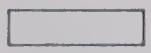
1) In preparation

Measuring Setup configurations of the series types 6 and 60

Summary of controllability of Level Generators and Level Meters

Basic units

Level Generator	PS-6	BN 340
Level Generator	PS-60	BN 610
Level Generator	PSS-60	BN 610/2
Level Meter	SPM-6	BN 341/4
Level Meter	SPM-60	BN 611
Fixed Frequency Attachment	FFZ-6	BN 434
Sweep Frequency Unit	WZ-6	BN 408



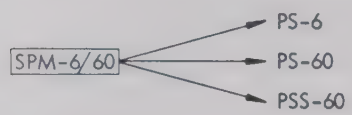
Controlling equipment

Equipment combinations

Generator with external tuning

Receiver with external tuning

Level Measuring Setup with synchronized tuning



Level Measuring Setup with external tuning

Swept Frequency Generator

Swept Frequency Measuring Setup with Wideband Plug-in

Applications

Pilot level measurements while lines are actually carrying traffic;

Level measurements at repeated measuring frequencies in production and test departments.

Attenuation and gain measurements.

Attenuation and gain measurements at repeated measuring frequencies (e.g. checking frequency response in test departments).

End-to-end swept frequency measurements (without auxiliary connections);

Swept frequency measurements in test departments.

1) For detailed specifications see Specification Sheets SG-2 or SG-3

1. SPECIFICATIONS

1. SPECIFICATIONS

Unless otherwise stated, the specifications are valid for the permissible range of a.c. line voltage for the rated range of use of the temperature immediately after the set is switched ON.

1.1. Frequency

Frequency range . . . . . 2 kHz to 18.6 MHz
Frequency setting . . . . . continuously tunable through the entire range
Additional fine detuning/retuning, mean detuning range . . . approx. ± 800 Hz
Frequency readout . . . . . through frequency counter with 6 digit, flicker-free illuminated numeric display

Frequency readout resolution, switchable . . . . . 1 kHz, 100 kHz, 10 Hz
Measuring rate . . . . . 77, 8, 3.2 Meas./sec.
Accuracy limits at + 20° C [1] . . . . . $\pm 4 \times 10^{-6} \pm 1$ unit of the last displayed place

Mean temperature coefficient in limits range of use of ambient temperature referred to + 20° C . . . . . $\leqq \pm 3 \times 10^{-7}$/° C

1.2. Level indication

with automatic amplitude calibration, switchable to voltage level (0 dB ≅ 0.775 V) or power level (0 dBm ≅ 1 mW into 75 Ω)
Measuring ranges for 0 dB meter reading . - 110, - 100, - 90, - 88, - 86, to, + 20 dB
- 100, - 90, - 80, - 78, - 76, to, + 26 dBm

Meter scales
Scale range 20 dB . . . . . - 22 to + 1 dB
Scale range 2 dB . . . . . - 2.2 to + 0.3 dB
Scale range ± 0.5 dB (level magnifier). . . . . - 0.5 to + 0.5 dB

Smallest readable level difference
Scale range 2 dB . . . . . 0.02 dB
Scale range ± 0.5 dB . . . . . 0.01 dB

Level magnifier, setting range of gain . . . . . approx. 2.5 dB

Accuracy limits of input level reading
Accuracy limits of level reading in range 0 dB (+ 10 dBm) at 0 dB reading in scale range 2 dB and at + 20° C
f = 20 kHz to 6 MHz . . . . . ± 0.1 dB
f = 6 kHz to 18.6 MHz . . . . . ± 0.15 dB
f = 2 kHz to 6 kHz . . . . . ± 0.2 dB

Accuracy limits of variation with frequency in the level ranges - 90 to + 10 dB (-80 to + 20 dBm) in frequency range of 6 kHz to 18.6 MHz . . . . . 0.1 dB

Accuracy limits of measurement range switch for f = 6 kHz to 18.6 MHz referred to setting 0 dB (+ 10 dBm) in the ranges [2]
- 90 dB to 8 dB (-80 dBm to + 18 dBm) . . . . . ± 0.05 dB [3]
+ 10 to + 20 dB (+ 20 to + 26 dBm) . . . . . ± 0.08 dB
- 100 dB, - 110 dB, (- 90 dBm, - 100 dBm) . . . . . ± 1 dB

Accuracy limits of meter scale referred to 0 dB scale mark
Scale range 20 dB . . . . . ± 1 % f.s.d.
Scale range 2 dB . . . . . ± 0.03 dB
Scale range ± 0.5 dB . . . . . ± 0.015 dB

Max. average temperature coefficient in limits range of operation of ambient temperature referred to + 20° C at 0 dB meter reading:
in scale range 2 dB . . . . . ± 0.005 dB/° C
in scale range ± 0.5 dB . . . . . ± 0.007 dB/° C

1. SPECIFICATIONS

Uncertainty of meter reading due to superimposed noise in the scale ranges 2 dB and ± 0.5 dB with "slow" meter readings and at 75 Ω input impedance

Measuring ranges : - 90 to + 8 dB (-80 to + 18 dBm) . . . . approx. ± 0.005 dB
+ 10 to + 20 dB (+ 20 to + 26 dBm) . . . . approx. ± 0.01 dB
- 100, - 110 dB (- 90, - 100 dBm) . . . . approx. ± 0.15 dB

Deflection caused by noise with open input, 75 Ω input impedance and bandwidth 1.74 kHz in position : - 90 dB (- 80 dBm) . . . . . ≦ - 112 dB (- 102 dBm)
- 100 dB (- 90 dBm) . . . . . ≦ - 122 dB (- 112 dBm)
- 110 dB (- 100 dBm) . . . . . ≦ - 126 dB (- 116 dBm)

Fast signal detector
Threshold referred to 0 dB meter reading :
in scale range 20 dB . . . . . approx. - 20 dB
in scale range 2 dB . . . . . approx. - 2.1 dB

1.3. Input impedance

Switchable, coaxial . . . . . 75 Ω and 10 kΩ II approx. 45 pF

Return loss coefficient at input impedance 75 Ω
in range - 100 dB to + 20 dB (- 90 dBm to + 26 dBm) . . . . . ≦ 0.02
in range - 110 dB (- 100 dBm) . . . . . ≦ 0.05

Permissible input voltage (overload point)
At input impedance : 75 Ω . . . . . V_{rms} ≦ 10 V
10 kΩ : a.c. voltage . . . . . Vp ≦ 25 V
d.c. voltage . . . . . V ≦ 42 V

1.4. Selectivity

Switchable
"Wide"
3 dB bandwidth . . . . . 2.3 kHz
Equivalent-noise bandwidth . . . . . 1.74 kHz
Rejection at $\Delta f \geqq \pm 2$ kHz . . . . . ≧ 30 dB
$\Delta f \geqq + 4$ kHz . . . . . ≧ 60 dB

"Narrow"
3 dB bandwidth . . . . . 500 Hz
Equivalent-noise bandwidth . . . . . 400 Hz
Rejection at : $\Delta f \geqq + 1$ kHz . . . . . ≧ 30 dB
$\Delta f \geqq \pm 1$ kHz . . . . . ≧ 60 dB

IF suppression . . . . . ≧ 80 dB
Image frequency supression . . . . . ≧ 80 dB

1.5. Self introduced harmonic ratio

Self introduced harmonic ratio in the settings "low distortion" for input level ≦ + 10 dB (+ 20 dBm) for k_2 and k_3 with a 50 dB increase of sensitivity referred to the fundamental frequency measuring range : f ≧ 300 kHz . . . . . 75 dB
f < 300 kHz . . . . . 65 dB

Low distortion ranges . . . . . - 30, - 50, - 70, - 90, - 110 dB
- 20, - 40, - 60, - 80, - 90, - 100 dBm

The SPM-60 has a push button for checking linearity

1. SPECIFICATIONS

1.6. Outputs

Unbalanced
Open circuit voltage for 0 dB meter reading, loadable to short circuit
D.C. voltage output, Z_{out} = 5 kΩ . . . . . 4.3 V
Demodulator outputs, Z_{out} approx. 4 kΩ . . . . . .
Single sideband demodulation, upright or inverted position . . . approx. 500 mV

Control outputs for remote tuning of the PS-60, PS-6 or PSS-60
Carrier signal 24 to 42.6 MHz (Bu 2401), Z_{out} = 75 Ω . . . . . V_{rms} = 40 mV across 75 Ω load
Standard frequency 1 MHz (Bu 2402), Z_{out} = 75 Ω . . . . . V_{rms} = 200 mV across 75 Ω load

1.7. General Specifications

Permissible ambient temperature
Limits range for storage and transport . . . . . - 40° C to + 60° C
Limits range of use . . . . . - 10° C to + 50° C
Rated range of use . . . . . + 10° C to + 35° C

Power supply . . . .

a.c. line voltage, adjustable	rated range of use
110 V	93.5 V to 121 V
117 V	100 V to 129 V
127 V	109 V to 141 V
220 V	187 V to 242 V
227 V	193 V to 250 V
235 V	202 V to 262 V

Rated range of use of a.c. line frequency . . . . . 45 to 440 Hz
Power consumption . . . . . approx. 20 VA
Protective class I

Dimensions . . .

Bench model		19" rack mounting (DIN 41494)	
Width with handles	478 mm	Width	443 mm
Height overall	199 mm	Height	176 mm
Depth with handles	407 mm	Depth	353 mm

Weight . . . . . 18.5 kg

1.8. Measuring accessories

Test Probe TK-9

Passive test probe
Unless otherwise noted, the values are valid for 20° C ambient temperature

Frequency range . . . . . 50 kHz to 18.6 MHz
Attenuation in frequency range 50 kHz to 15 MHz . . . . . 20 dB ± 0.1 dB
Input impedance . . . . . approx. 5 kΩ II 17 pF
Permissible ambient temperature . . . . . - 10 to + 50° C

Connectors: Universal connector Versacon ® 9 for all usually used types of connectors or test prods

Test Probe TK-12 with Power supply TKN-12

Active Test Probe (preliminary specifications)

Frequency range: balanced . . . . . 200 Hz to 2 MHz
unbalanced . . . . . 200 Hz to 18.6 MHz

1. SPECIFICATIONS

Gain, adjustable 1

Accuracy limits of variation with frequency, referred to 1 MHz
in range 200 Hz to 2 MHz . . . . . ± 0.05 dB
in range 200 Hz to 18.6 MHz . . . . . .± 0.5 dB

Maximum level . . . . . + 2 dB

Input impedance: balanced, at f = 10 kHz . . . . . .approx. 1 MΩ II 25 pF
unbalanced: at f = 10 kHz . . . . . .approx. 1 MΩ II 15 pF
at f = 18.6 MHz . . . . .approx. 10 kΩ II 15 pF

Common mode rejection in range 200 Hz to 2 MHz . . . . . ≧ 40 dB
Impedance balance ratio in range 200 Hz to 2 MHz . . . . . ≧ 40 dB
Self introduced harmonic ratio: at 0 dB and f = 20 kHz . . . . . ≧ 60 dB
at 0 dB and f = 6 MHz . . . . . ≧ 40 dB

Coaxial connection: Universal connector Versacon® 9 for all usually used types of connectors or test prods

Standard accessories . . . .1 coaxial connector and test prod with earthing clamp
Available at extra cost . . . . . .balanced CF connector

Power supply:
Power supply for TK-12 . . . . . TKN-12

1.9. Ordering Information

Selective Level Meter SPM-60	BN 611/0
With 1020 Hz output for phase-jitter measurements	BN 611/4
As for BN 611/4, but with additional 24 Hz bandwidth	BN 611/5
Measuring accessories (at extra cost)	
Inverter WR-420	BN 678
Passive Test Probe TK-9	BN 265
Active Test Probe TK-12 with Power Supply TKN-12	BN 574 and BN 623
Transportation Protective Cover for SPM-60	DE 3

Subject to change without notice

1) For equipments of Series A and B, the accuracy is decreased by ± 5 Hz.

2) When the Generator is remotely controlled through the Level Meter and readout of the send level, the given accuracy is decreased by ≦ 0.03 dB.

3) In the frequency range f = 2 kHz to 6 kHz, the accuracy is decreased by 0.03 dB.

2. OPERATION

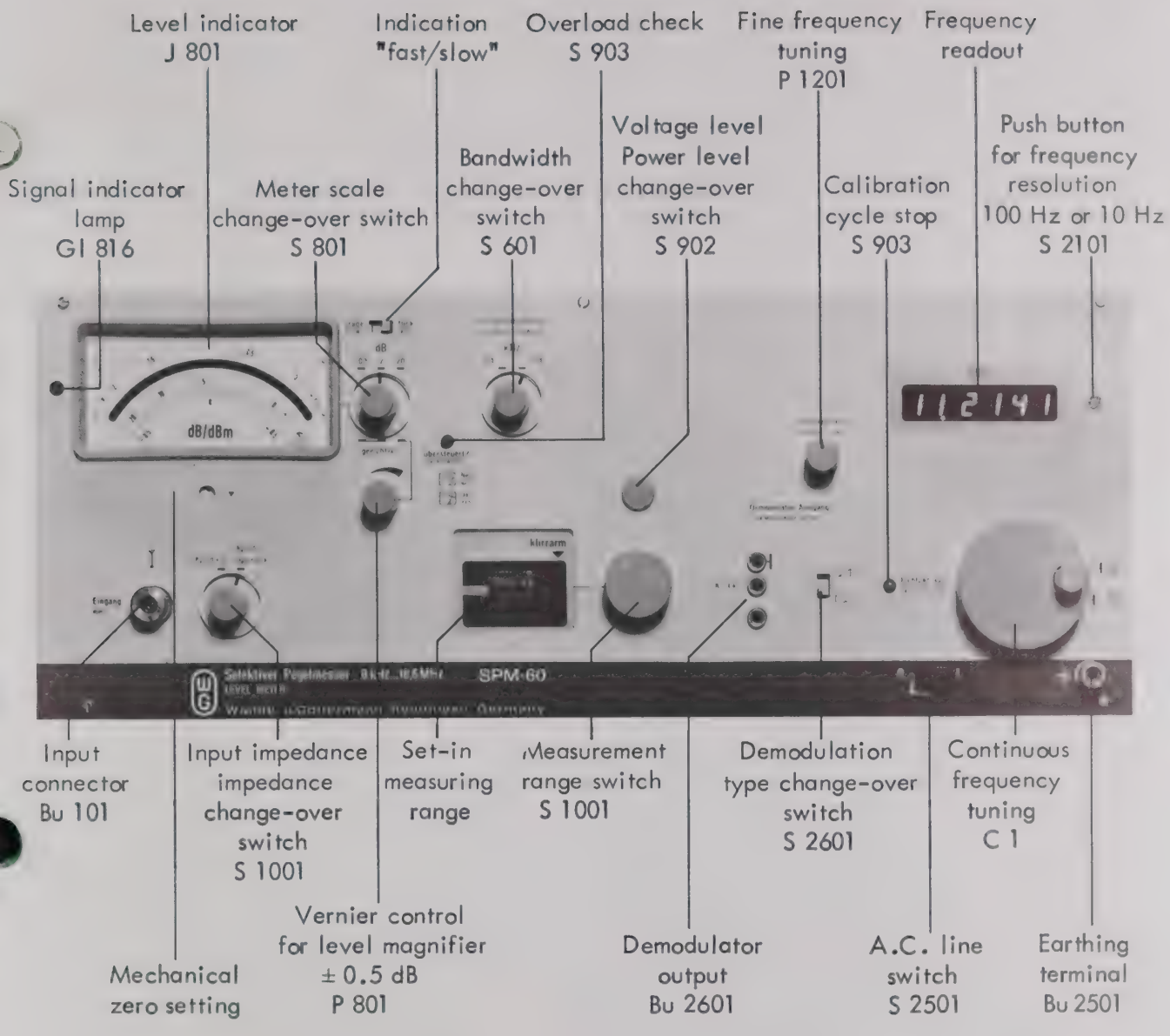

Level indicator
J 801
Indication
"fast/slow"
Overload check
S 903
Fine frequency
tuning
P 1201
Frequency
readout
Signal indicator
lamp
GI 816
Meter scale
change-over switch
S 801
Bandwidth
change-over
switch
S 601
Voltage level
Power level
change-over
switch
S 902
Calibration
cycle stop
S 903
Push button
for frequency
resolution
100 Hz or 10 Hz
S 2101
dB/dBm
SPM-60
Input
connector
Bu 101
Input impedance
impedance
change-over
switch
S 1001
Set-in
measuring
range
Measurement
range switch
S 1001
Demodulation
type change-over
switch
S 2601
Continuous
frequency
tuning
C 1
Mechanical
zero setting
Vernier control
for level magnifier
± 0.5 dB
P 801
Demodulator
output
Bu 2601
A.C. line
switch
S 2501
Earthing
terminal
Bu 2501

Fig. 2-1

D.C. voltage output
Bu 801
Bu 402
Control outputs
Bu 2401
A.C. line connection
St 2501
Fuse
Si 2501

Fig. 2-2

2. OPERATION

2.1. Installation of the equipment

The Level Meter SPM-60 is designed for operation either as stationary or as mobile equipment.

2.1.1. Operating controls

The control knobs, indicating devices as well as the input connectors for the measuring signal are arranged on the front panel for a good over-all view.

Power line connection, control outputs and the d.c. voltage output are located on the back panel.

The positions of all operating controls can be seen on Fig. 2-1 and 2-2.

2.2. Connecting and commissioning the SPM-60

2.2.1. Mechanical zero point

Before the SPM-60 is switched ON, the mechanical zero point "▼" of the meter should be checked and corrected.

2.2.2. A.C. power line operation

The SPM-60 is delivered from the factory with the mains voltage set for 220 V a.c. If a different line voltage is used, then an easy adjustment at the mains voltage selector switch is possible. The voltage selected is seen through a cut-out on the equipment right panel.

In the mains voltage range 220/238 V, the fuse is 0.125 A slow-blow. When changed-over to the 110/128 V range, the fuse should be 0.25 A slow-blow.

2.2.3. Operation free of power lines

Mobile applications are enabled by means of the Inverter WR-420 which permits power to be taken from an external battery. The Inverter can be used with battery voltages as selected of 12 V, 24 V, 36 V or 48/60 V.

The WR-420 supplies two voltage ranges:
220 V/400 Hz or 117 V/400 Hz. Output voltage is sinusoidal. Power out is 20 VA. Each equipment in the complete Level Measuring Setup PS-60/SPM-60 requires one Inverter WR-420.

2.3. Measuring

The measuring voltage is fed in via a suitable cable. The input impedance remains linear when the Level Meter is changed-over so possible switching effects at the test specimen are prevented.

If the input signal is not present, then the pointer on the analog meter stays at the extreme left.

2.3.1. Measurement input; input impedances

Measurements on coaxial systems in the frequency range 2 kHz to 18.6 MHz are made via input connector Bu 101. The input impedance can be changed-over at S 101 either for Z_{in} = 75 Ω or for Z_{in} = 10 kΩ, depending on the measuring requirement.

2.3.2. Setting the receive frequency

2.3.2.1. Continuous tuning of frequencies

The desired receive frequency can be continuously tuned within one range.

With the coarse tuning = tuning knob depressed, the frequency readout appears as 5 digits through a window on the front panel (resolution 1 kHz).

With fine tuning = tuning knob pulled out, i.e. fine mechanical drive (ratio 20 : 1), the readout is 6 digits (resolution 100 Hz). Furthermore, the potentiometer "FREQUENCY FINE" provides an especially accurate tuning capability. The vernier tuning feature has a range of approx. 200 Hz at low frequencies and 1.5 kHz at high frequencies. This vernier setting should be used at a resolution of 10 Hz, for instance it has a special advantage with pilot level measurements because of the accurate resetting feature. Thereto, if the tuning knob is pulled out, depressing the push button next to digital readout [1] causes the decimal point to be shifted one place to the left, and the first digit disappears from the readout range.

If the readout is 5 digits (coarse tuning), then depressing the previously mentioned push button causes the readout to be 6 digits (resolution 100 Hz).

2.3.2.2. Remote control of PS-60, PSS-60 and PS-6

If the Generator and Level Meter are to be operated at the the same location, the frequency of any Generator listed above can be synchronously tuned from the SPM-60 if an auxiliary cable is connected between.

The cable connection is illustrated in the following figure:

1) With the occurrence of tuning lower then zero, the counter readout is 99.9999 MHz. Obviously, this readout is not valid (frequency limit 18.6 MHz), however, it does appear due to the design of the counter.

2. OPERATION

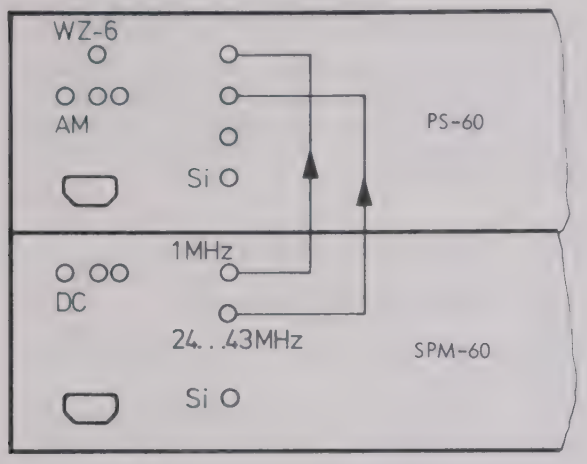


Fig. 2-3

2.3.3. Level reading

2.3.3.1. Measuring ranges encompassed analog meter

The analog meter J 801 has the following three scale ranges:

unexpanded scale:	- 22 dB to + 1 dB
expanded scale:	- 2.2 dB to + 0.3 dB
expanded scale (level magnifier):	- 0.5 dB to + 0.5 dB

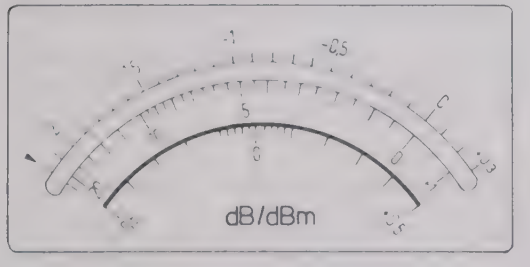


Fig. 2-4

2.3.3.2. Absolute level measurements

The measuring ranges were selected to be 20 dB, 2 dB and ± 0.5 dB, this came about because of the various measurement tasks arising in practice and can be expressed as:

1) Measurement of a signal whose amplitude is almost the same as the sum of the signals present at the input to the Level Meter.

Under this category, most of the usual level measurements occur, especially the measurements which are to be made with the highest possible accuracy. For this reason, the analog meter J 801 should be used with the expanded scale of 2 dB. Measuring range switch S 801 permits the choice of range where reading is most easily done.

When searching for unknown signals or for scanning type measurements, the measurement scale of 20 dB on analog meter J 801 also can be used.

The measured level results from the sum of the value set-in at the measurement range switch plus the reading of the scale value taking into account the setting of the scale range switch.

2) Measurement of a signal whose amplitude is essentially smaller then the sum of signals present at the input to the Level Meter. This is mainly the case with distortion ratio measurements, determining intermodulation products, noise voltage measurements on an in-service CF system and similar cases.

The measurements of that type are made with the 20 dB scale of analog meter J 801.

Therefore, it is necessary to observe that the input stages are presented with signal-drive from both the signal to be measured as well as the summed signal of higher magnitude. So with the worst case, measurement errors can occur For this reason, the described measurements preferably should be made in the indicator field "white", which identifies low distortion level measuring ranges (- 30, - 50, - 70, - 90, - 100, - 110 dB).

Also for the measurement of very low levels (set-in measuring range - 100 dBm or - 110 dB), it is worthwhile to change to the 20 dB scale (unexpanded range).

2.3.3.3. Relative level measurements

For a series of measurements e.g. the determination of variations with frequency, the absolute values are not as important as the deviations from a previously provided reference value.

If the meter scale change-over switch is used so after a measurement is made in the 2 dB range that the position "± 0.5 dB" is selected, then the use of potentiometer P 801 permits any chosen meter reading in the 2 dB range to be shifted to the centre of the scale, i.e. 0 dB reading. Thereby, the smallest deviations to 0.01 dB of relative level can be read with increased accuracy from the scale divisions of 0.02 dB on each side of the 0 dB scale mark.

However, it is very important to observe that, in the ± 0.5 dB scale range, the reading is no longer absolutely calibrated.

Potentiometer P 801 has a coarse and fine drive mechanism (1 : 10) on one shaft.

2.3.3.4. Meter reading change-over

If the meter reading is rapidly fluctuating, then the meter can be switched from fast to slow. This possiblity exists for all three positions of the range change switch.

2.3.3.5. Overload check

Measurement errors caused by overload (over-driven signals) can be easily recognized after the OVERLOAD push button S 901 is depressed. If the pointer of the analog meter remains steady, then the measurement is correct. If, however, the pointer oscillates at a 1 Hz rate then the measured result indication is not valid. The signal drive in the Level Meter must be reduced with the

range switch S 1001 which reduces the sensitivity until the OVERLOAD check indicates that the measurement does not suffer from an overloaded condition. Thereby, switch S 802 remains in position "FAST".

2.3.3.6. Voltage level – power level calibration

The Level Meter can be changed-over by means of S 902 from voltage level calibration 0 dB ≅ 0.775 V (= 1 mW across 600 Ω) to power level calibration 0 dBm ≅ 1 mW into Z (Z = 75 Ω).

The reference value dB or dBm appears in the indicator window.

2.3.3.7. Signal indicator

The fast signal indicator serves as a tuning aid in searching for unknown receive signals. The signal indicator lamp GI 816 illuminates as soon as a voltage sufficient to cause a meter deflection is present at the input. Since fast tuning through the range of frequencies can be too fast the meter pointer to respond, the lamp takes over to indicate the presence of a measurable voltage.

2.3.3.8. Bandwidths

The equivalent-noise bandwidths of the Selective Level Meter SPM-60 can be changed-over, depending on the measuring problem at hand, between 1.74 kHz and 400 Hz.

The wider bandwidth is used when unknown receive frequencies are being searched for during noise measurements, and when the demodulator device is in use; whereby the narrow bandwidth is used to advantage for instance to analyze adjacent signals and when the signals are noisy. If so chosen, the Level Meter may be fitted with an additional narrow-band filter [1] having an equivalent-noise bandwidth of 24 Hz. This filter permits narrow-band in-service measurements on group and super group pilots.

2.3.3.9. Calibration cycle switch-off

To simplify tuning during narrow-band level measurements, depressing push button S 903 (next to the frequency tuning knob) causes the calibration cycle to be interrupted

If the input signal is too low or not present at all, the Level Meter automatically switches off the calibration cycle. Therewith, the Level Meter is constantly in the position "MEASURE".

2.3.3.10. Demodulator device

The inbuilt demodulator device enables the demodulation of amplitude modulated signals, and the demodulator output Bu 2601 (front panel) presents the demodulated signals.

Change-over switch S 2001 permits selecting the type of demodulation:

demodulation of the upper sideband (upright position)

or

demodulation of the lower sideband (inverted position)

For correct demodulation, the receive frequency should be detuned by about 1.35 kHz either above or below the carrier. The upright position is at approx. + 1.35 kHz and for the inverted position, approx. - 1.35 kHz. Meter readings and calibration cycle remain in operating status. If the calibration signal interferes, then the calibration can be blanked by means of the push button.

2.3.3.11. D.C. voltage output

Output Bu 801 supplies a d.c. voltage proportional to the meter reading This is 0 to 5 V, according to the corresponding pointer deflection. Output impedance is 5 kΩ. Due to the SPM-60 having a high stability of gain as a result of the automatic level calibration, the d.c. output is suitable for permanent monitoring by means of X-Y recorder, oscilloscope or similar equipment

The output connector Bu 801 is connected in a way that + is at the centre at "a", whereby "b" and "c" are connected to the chassis-ground.

1) In preparation for equipments commencing with Series C (can be retrofitted commencing with Series D)
BN 611/5

3. TECHNICAL INSTRUCTIONS

4. FUNCTIONS AND CHARACTERISTICS

4. FUNCTIONS AND CHARACTERISTICS

The Level Meter SPM-60 is a receiver which operates according to the principle of multiple conversion having four different intermediate frequencies (IF's). The last IF is at 10 kHz where the most gain and selectivity is achieved. This signal is then rectified and indicated on a meter.

Simultaneously, the indicated voltage also is presented at a d.c. output connector, and there is no possibility of feedback from the load. An output from the demodulator provides the opportunity of checking single-side-band signals. At two other outputs, there are the signals needed for the remote control tuning of frequencies at the Generators PS-60, PSS-60 or PS-6.

Such high accuracy for measuring levels is attained by means of an automatic calibrator for levels. This operates at a 1 Hz repetition rate. At this rate, the gain is checked at the pertinent tuned frequency and at the level measuring range used at that time. Then, within the same interval, the gain automatically is reset to the nominal value. A push button, for checking, enables a rapid and easy verification to determine if the Level Meter is being overdriven.

This feature prevents errors in measuring when there are large differences in levels at various frequencies presented at the input to the SPM-60.

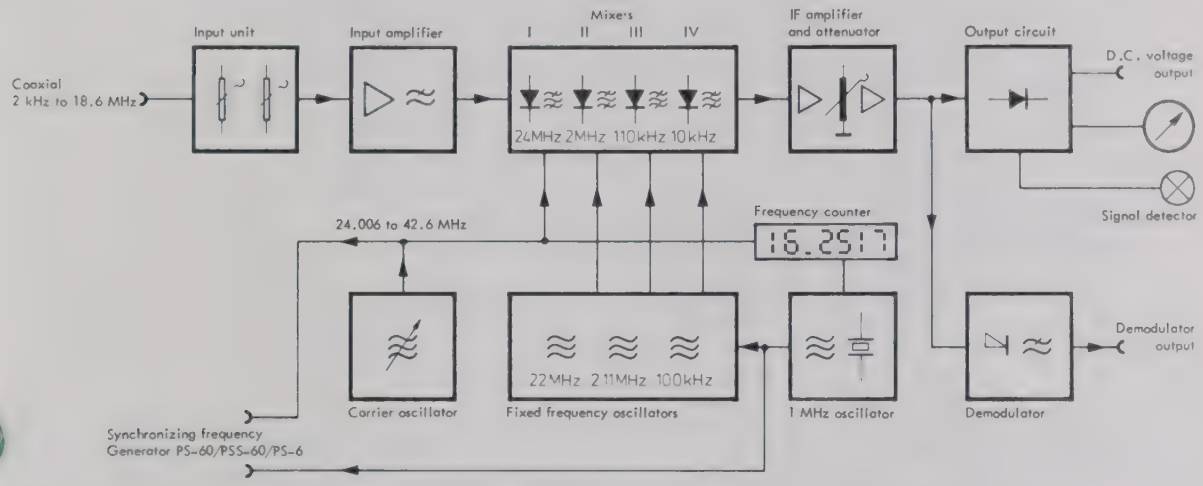


Fig. 4-1

4.1. Automatic level calibration

By means of the automatic level calibration, the long term stability of level measurement is as good as the inbuilt calibration level source whose verification results from the use of a silicon reference element. Thereby, the variation with frequency of the entire equipment, and the attenuator accuracy are reduced to the accuracy of the ratio-transformer type of IF voltage divider. See Fig. 4-2.

Additionally, automatic calibration considerably simplifies operating the Level Meter. The frequency of the calibration source is obtained by down-conversion of the carrier frequency f_T (16) and the frequency f_{ZT} = 24 MHz from PLL cal. oscillator (22), phase locked to a crystal control oscillator. Therefore, the calibration frequency switches alternately for approx. 1 s to "MEASURE" and for approx. 0.1 s to "CALIBRATE". Since the calibration level is fed in before attenuator I, this attenuator and the error due to variation with frequency are included. Simultaneously, during the calibration cycle the extremely accurate ratio-transformer attenuator II is automatically changed accordingly to track with the setting of attenuator. Thus the sensitivity of the entire set always remains the same and independent of the setting of attenuator I. The converted, amplified and rectified calibration signla is then compared to a highly stable reference voltage V_{ref}. IF there are deviations from the nominal gain, probably caused by errors in attenuator I as well as variations with frequency, then an automatic level amplifier takes on the corresponding corrective action. This resetting of the gain does not take place during the next measuring interval, but the ratio-transformer attenuator II automatically is reset to the setting corresponding to the externally adjusted measuring sensitivity of the Level Meter.

From the continuous change-over between "MEASURE" and "CALIBRATE", a small difference of nominal gain results, however, this is virtually negligible because of the high accuracy of attenuator II. A memory circuit retains the readout at the last result from the previous measuring interval, thus the level readout is not disturbed by the calibration process. During the calibration interval, a substitute load is at the input of the Level Meter, so the return loss coefficient is not changed during this time.

4. FUNCTIONS AND CHARACTERISTICS

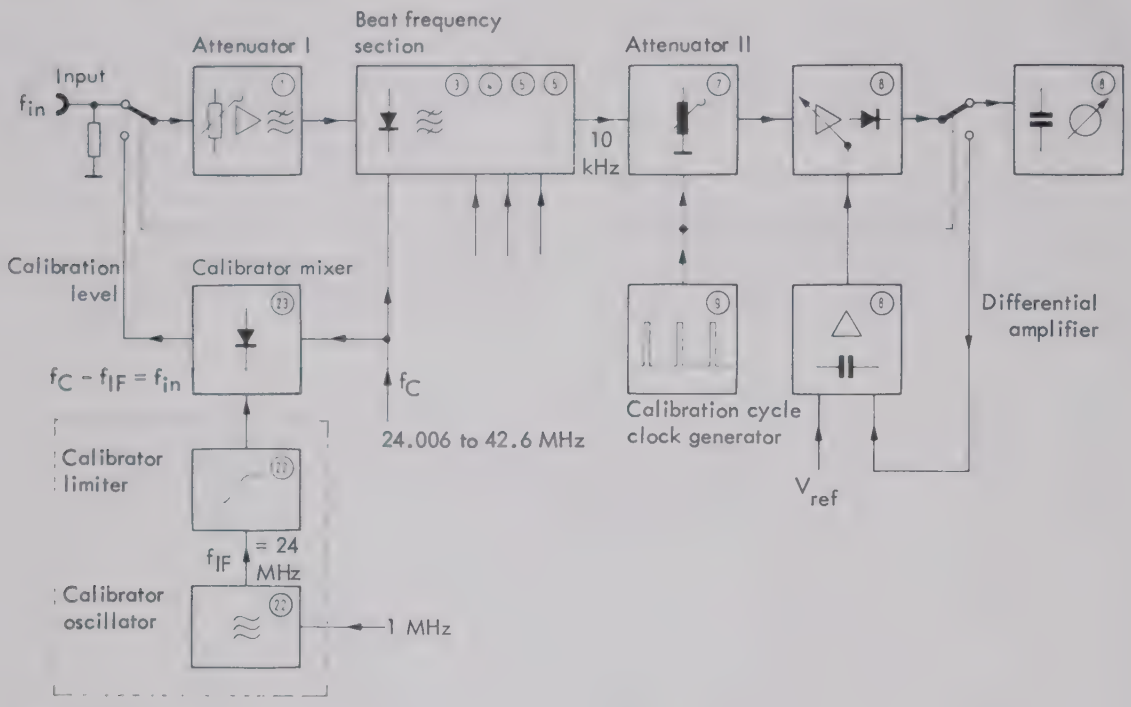


Fig. 4-2

4.2. Overload control

After the OVERLOAD control push button is actuated, with the start of the next calibration cycle at the input to the Level Meter, the gain is raised by about 1 dB. In the same rhythm, the gain in the 10 kHz amplifier is decreased by the same amount, so in fact the overall gain remains constant: input amplifier and mixer, however, are driven by 1 dB higher level.

When the Level Meter is operating linearly, the level reading does not change in the succeeding measuring interval, but if the Level Meter is overdriven, then the level reading increases. If the OVERLOAD push button is depressed for a short time, then the OVERLOAD check results during the next measuring interval.

With a continuously depressed push button, the OVERLOAD check takes place every second measuring interval. An overdriven condition (OVERLOAD) manifests itself as a periodic fluctuation at a 2 second rate.

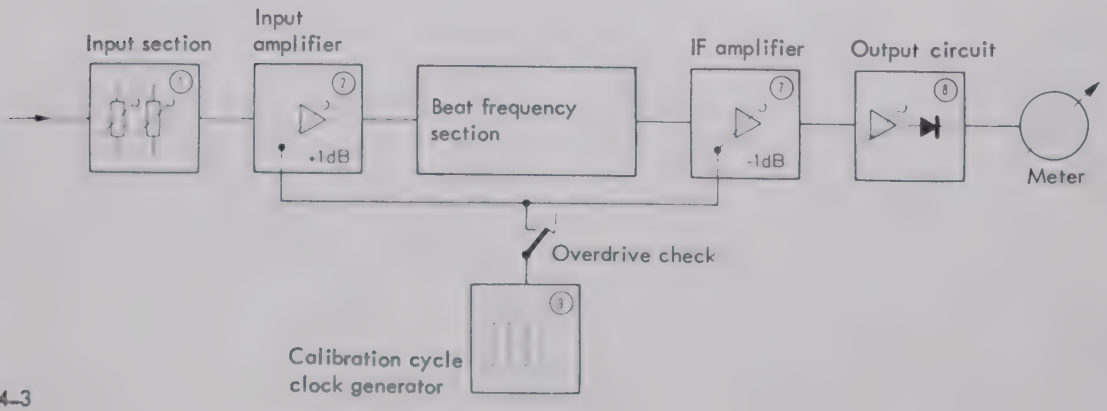


Fig. 4-3

4. FUNCTIONS AND CHARACTERISTICS

4.3. Frequency generation

The 24 MHz oscillator is phase locked to the 1 MHz crystal controlled oscillator.

The carrier frequency f_T, tunable from 24 to 42.6 MHz, is used to control the mixer. It is derived from tripling the control frequency f_{St} which is continuously tunable in the range 8 to 14.2 MHz due to the LC control oscillator.

Tripling is done with the aid of a phase locked loop (PLL) whose tracking range magnitude is formed by the control oscillator. Thus, the carrier frequency is divided in the ratio 3 : 1. Then it is compared with the control frequency in a phase comparator circuit whose output voltage is proportional to both frequencies and stabilizes the carrier oscillator at $f_T = 3 \times f_{St}$

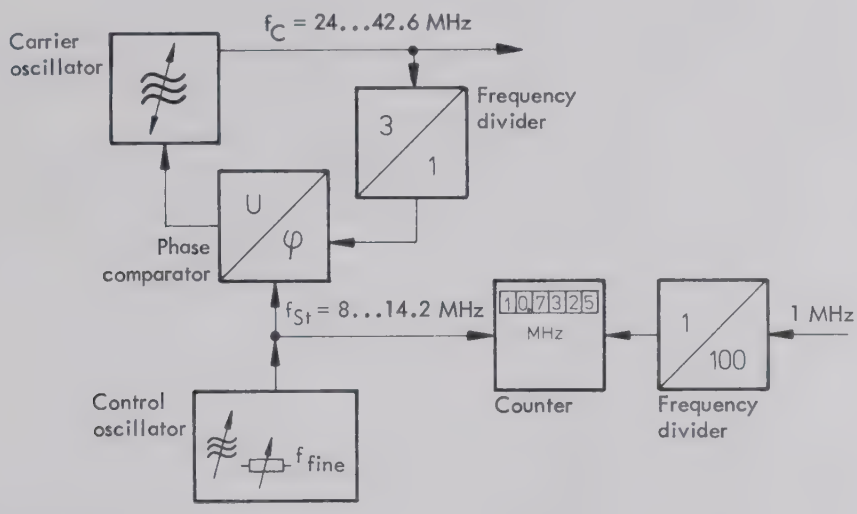


Fig. 4-4 Simplified block diagram of the carrier frequency generation

4.4. Frequency readout

Readout of the set-in frequency is done at the 6 digit numeric display of the crystal controlled frequency counter. To ensure that the frequency is always correctly displayed in the utilized frequency range of 2 kHz to 18.6 MHz, the preselection and open gate time of the counter must be correspondingly chosen. The measuring interval is obtained from dividing the crystal controlled 1 MHz oscillator frequency. The number of measurements per second is correlated with the resolution as follows:

Resolution: 1 kHz (5 digit readout) 80 measurements/s
Resolution: 100 Hz (6 digit readout) 8 measurements/s
Resolution: 10 Hz (6 digit readout) 3 measurements/s
+ decimal point shift

The counter essentially comprises along with the time-base and counter control of the counting circuit, the buffer, decoder/driver and the digital readout display. A prominent feature is the flicker-free numeric display of frequency. A new circuit eliminates the flicker, but with 10 resolution when the push button is depressed, the circuit is inoperable.

4.5. Output circuit / signal detector

A fast signal detector permits an LED to indicate the presence of both a signal voltage at the measurement input and also within the indication range of the analog meter. This results from the 10 kHz IF voltage whose amplitude is a function of the adjustable gain amplifier. The gain is adjusted when the meter scale is selected. The amplifier output is fed to a meter detector. Furthermore, the positive half-waves control a Schmitt trigger circuit whose output signal toggles a mono-stable circuit which conducts for 100 ms (approx.) during which the LED is lit.

5. MAINTENANCE AND GENERAL INFORMATION

5. MAINTENANCE AND GENERAL INFORMATION

Danger: Before the cabinet is opened, the a.c. power line should be disconnected

5.1. Mechanical assembly

The cabinet dimensions correspond to the new DIN Standard 41 494 and the USA Standards, RETMA, as well as ASA C 83.9. Accordingly, the equipment can be mounted in a 19" rack.

Cover, base plate, back panel and side panels are manufactured out of plastic covered aluminium sheetes. After removal of the corresponding screws on the back panel, the chosen panel can be pulled out backwards. Thereupon, the switches and circuit elements are accessible. In order to obtain access to the subassemblies at the centre of the equipment, subassemblies (6), (7), (8), (9) and (26) are fabricated on a folding subchassis, and after removal of two screws and the drive coupling, the subchassis may be unfolded outwards.
If the chassis must be completely removed for instance to change components, then only a "Subminix" plug as well as a multi-pin Amphenol plug and the right hanger (hinge) need be removed.

5.2. Switch maintenance

To prevent mechanical wear at the switch, the indents should have periodic reapplication of switch lubricant.

5.3. Changing fuses

The fuse holder is located on the back panel of the equipment. After the cap has been unscrewed, the fuse is accessible and can be exchanged. Make sure that the correctly rated fuse is replaced! See paragraph 2.2.2.

5.4. Universal connectors Versacon® 9

The coaxial input and the control outputs for remote control of the PS-60, PSS-60 or PS-6 are fitted with the new Universal connectors of Wandel u. Goltermann. These have the advantage that adaptors can be changed quickly for the connector types listed below. No resoldering is needed, only a mounting wrench is used (order number W1).

Versacon® 9 | Lemo | BNC | 1.6/5.6 | 2.5/6 | 1.6/10 | 558A | 470C Western Electric

Fig. 5-1

5.5. Mounting in a 19" rack

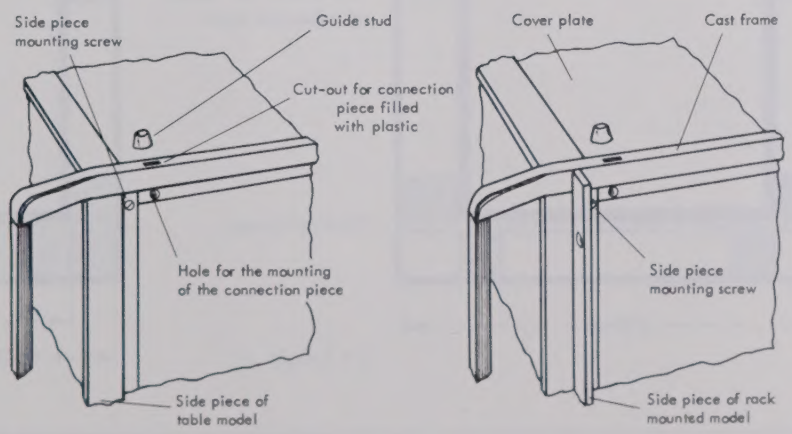

Side piece mounting screw
Guide stud
Cut-out for connection piece filled with plastic
Hole for the mounting of the connection piece
Side piece of table model
Cover plate
Cast frame
Side piece mounting screw
Side piece of rack mounted model

Fig. 5-2

5. MAINTENANCE AND GENERAL INFORMATION

If the equipment is to be mounted in a standard 19" rack, then the side pieces of the case frame must be replaced with special mounting brackets order number BN 556/4. The front panel dimensions are increased in width to that of the mounting dimensions for a 19" rack. After removal of two screws (see Fig. 5-2), the side pieces of the case can be exchanged for the brackets.

Cover and base plate are removed, then the feet and guide studs are removed. Side panels, cover and base plate are replaced and the screws are tightened.

5.6. Combining several equipments

The new cabinet conception allows the mounting of several instruments, one above the other. These instruments are firmly mounted together by means of special connection pieces, order number 00-0400.06/5.

To do this, it is necessary to remove the cover of the lower instrument and the base plate of the upper instrument as well as the side panels of both. The small plastic pieces in the frame cut-outs are now pushed out. This is done for the four cut-outs of the upper frame and the four cut-outs of the lower frame.

The four connection pieces are placed into the cut-outs of the lower instrument as shown in Fig. 5-3 and are screwed firmly into place. After removing the guide studs from the cover and the foot pieces from the base plate, both panels should be replaced.

The instruments are now placed one above the other so that the connection pieces, mounted in the frame of the lower instrument pass through the frame cut-outs of the upper instrument. After firmly screwing the upper instrument to the connection pieces, the side panels should be replaced.

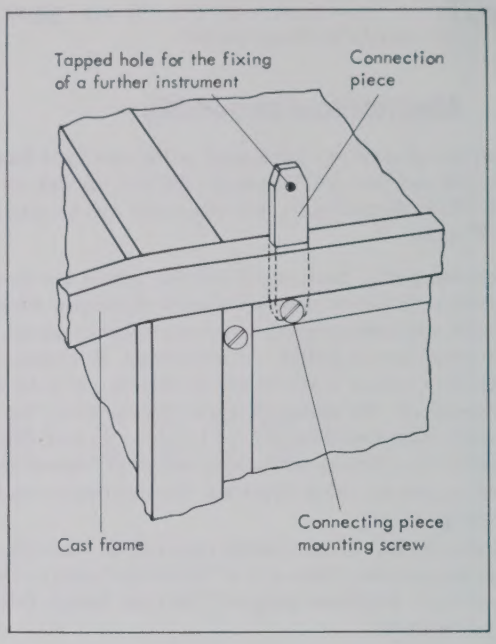


Fig. 5-3

5.7. Shipping instructions

Safe transportation of the equipment used in Measuring Set RK-5 can only be guaranteed if adequate packing is used. If the original packing has been discarded, the equipment should only be packed as shown in the following drawing, Fig. 5-4.

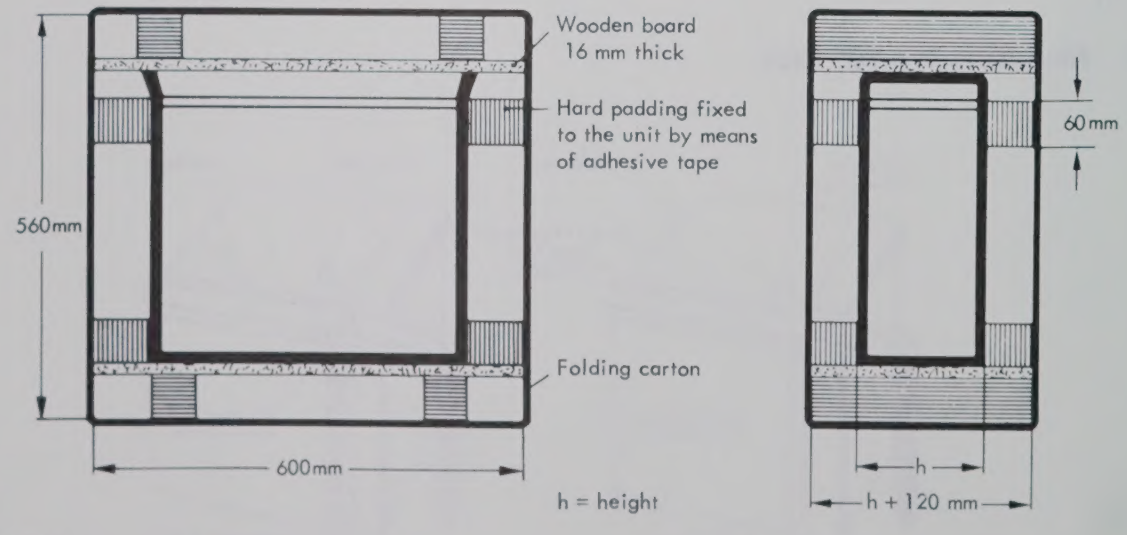


Fig. 5-4

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